THE SOCIAL LIFE OF MEASURES

Metrication in the United States and Mexico, 1789-2004

by

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> There are few activities more cooperative than the writing of history. The author puts his name brashly on the title-page and the reviewers rightly attack him for his errors and misinterpretations; but none knows better than he how much his whole enterprise depends on the preceding labours of others.[1]
>
> *Christopher Hill*

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[1] *The World Turned Upside Down: Radical Ideas during the English Revolution* (New York: Peregrine, 1984), 9.

its wonderful staff was kind and patient during all my visits and guided me to the Melvil Dewey Papers collection, which became a vital part of my research. The importance of the New York Public Library (particularly the Stephen A. Schwarzman Building and the Science, Industry and Business Library) for my work cannot be overestimated. I also made an extensive use of the three-headed system formed by the Elmer Holmes Bobst Library (New York University), the Fogelman Social Science and Humanities Library (New School), and the Library of the Cooper Union for the Advancement of Science and Art. In cyberspace, during the final years of my research I used the collections from the libraries of the University of Michigan, Harvard University, Stanford University, and the New York Public Library which became available through Google Books.

Weights and measures are not an obvious topic for a social sciences dissertation (way too many times when people asked me "What are you studying in your dissertation?" I replayed saying "the history of the metric system," just to receive suspicions looks and inquiries like "The metric system? Did you say you study *sociology*?") Fortunately I got early words of encouragement from professors who thought that meters, liters, and kilograms were indeed worthy of a doctoral dissertation; among them Jorge Bartolucci, Jose Casanova, Sarah Daynes, Eviatar Zerubavel, and Adriana Petryna.

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INTRODUCTION

Historical Sociology of Knowledge; Sociology of Measurement; Social History of the Metric System

> Unthankful only in appearance, metrological studies, in the hands of an intelligent researcher, became an instrument capable of revealing the great streams of civilization.[1]
>
> *Marc Bloch*

1. TOPIC, PROBLEM, QUESTIONS, CASES, METHOD

The metric system should be considered, under any standard, one of the most successful intellectual devices ever conceived. Very few ideas, if any, have penetrated so deep and so widely into humanity's collective mind as this system of measurement. It can be said, without sarcasm, that the metric system is more popular than Jesus—and more popular than The Beatles. Millions of people who have never read a line from the Bible think every day in terms of meters, liters, and kilograms to conduct their routine activities. What is more, you can mention any world religion, language, piece of global popular culture, or icon of globalization and their achievements will pale into insignificance in the light of what the metric system has done over the last two centuries.

Roughly speaking, today six and a half billion people around the globe use the metric system, which is approximately three times the number of Christians in the world (Christianity being the religion with the largest number of followers, with around 2.2 billion). The language with the biggest number of native speakers is Chinese, with 1.3

[1] Marc Bloch, "Le témoinage des mesures agraries," *Annales d'historie économique et sociale* 6 (1934), 280.

billion (i.e. one fifth of metric users); the language with the biggest total number of speakers is English, with 1.8 billion. Neither The Beatles nor Michael Jackson—the best-selling music artists in history—have sold more than one 1 billion records. Of course, I do not want to suggest here that the metric system has been more relevant, influential, or meaningful in world history than Christianity, for example; it is simply much more widely spread. This fact demands an explanation.

This dissertation is an attempt to develop a historically-grounded inquiry into large-scale processes of creation, distribution, control, monopolization, and appropriation of knowledge. More particularly, this is a study on *how a scientific language has been appropriated and signified by diverse institutions and social groups in different national contexts*. The scientific language that will be analyzed is the decimal metric system of weights and measures. The institutions and groups put under the microscope are states, commerce and industrial associations, scientists, rural communities, and laypeople. The national contexts in which these groups are observed are the United States and Mexico. The benchmarks that signpost the beginning and end of the period analyzed are 1789 (when the plans for the creation of the metric system started), and 1994 (when the North American Free Trade Agreement was formed).

With this study I want to underline, through an empirical investigation, that the analysis of historical processes is essential for any sociological theory of knowledge. In other words, I would like to contribute to the development of a *historical sociology of knowledge*. Secondarily, by studying the social life of a measurement system, it is my intention to shed light on the fruitfulness of studying weights and measures—understood as objects, conventions, and practices—from a sociological standpoint, pointing then to what may be called a *sociology of measurement*.

My present empirical research on the history of the decimal metric system attempts then to illuminate three main areas of inquiry in the sociology of knowledge:

1. The processes of trans-national and trans-generational diffusion of knowledge (this includes how a technical language is transplanted in different cultural contexts and how it is sustained to survive for decades or centuries).
2. The relationship between knowledge and power (e.g. the social distribution and monopoly of knowledge).
3. The appropriation of expert knowledge by the general public (i.e. how organizations, groups, and individuals go through the active and creative process of "taking possession of" or "making their own" a group of ideas and intellectual instruments).

One of the reasons that make the present investigation pertinent in the addressing of these problems is the uncanny success of the metric system, both in its geographical expansion (all the countries of the world except seven have adopted the metric system as their exclusive system of measurement) and in its penetration among social groups and classes (as it is used by microbiologists, peasants, machinists, butchers, and housekeepers alike). The immense majority of the people in almost all countries use the metric system as their main instrument of orientation when it comes to apprehending their own selves and their material environment (natural and artificial) in terms of quantities of length, volume, and weight.

The metric system was invented at the end of the eighteenth century by a couple of dozen savants from French learning societies, and for a couple of decades it was only understood and employed by fellow scientists and intellectuals; today ninety-five percent of the world's population live in countries where the metric system is the only legal system of measurement. In other words, since its creation the metric system made an incredibly successful transition from being a *special knowledge* (knowledge that is only possessed by a reduced group of specialists) to becoming *general knowledge* (knowledge that is routinely divulgated to all "normal" members of a society by the pertinent institutions, and it is socially defined as being relevant to everyone); and not only a general knowledge of a particular society, since it has become part of the social stock of knowledge of virtually all humanity.

My aim in this dissertation is to provide some answers as to what social and historical conditions account for the improvable but colossal accomplishment of the metric system, but also to elucidate the circumstances that have halted its development.

This problem opens three clusters of questions:

1) How a new idea (or set of ideas) enters into the social stock of knowledge (in this case humanity's social stock of knowledge). How are scientific languages appropriated by social groups in different national contexts? How the metric system supplanted hundreds of local measuring systems all over the world and defeated other newly invented systems to become the sole international system. What social conditions made this exceptional conversion possible?

2) How was it possible that the decimal metric system of weights and measures was adopted by ninety-five per cent of the world's population? Why the metric system succeeded in its quest for global expansion but similar projects (like the Republican calendar and the decimal system of time reckoning, invented at the same time as the metric measures) failed to do so.

3) What are the social circumstances that eventually halted the expansion of the metric system and have impeded its total global diffusion? Why the United States is the only Western country that has not adopted the metric system.

I shall examine these questions from different angles.

1. From the standpoint of the *state* I will analyze the metric system as a cognitive instrument used by states in the process of making territories, resources, and populations "legible." Also, I will show how nation-states have been the single most important factor to explain how global metrication was possible; it was them who adopted, regulated, and enforced the metric system among populations at large. States guaranteed the conditions necessary to achieve full metrication: policing the employment of metric units and providing populations with the intellectual and material means to learn the metric language. I argue that this was part of the states' interest in establishing a "monopoly on the legitimate means of measurement." Controlling weights and measures was a tool that allowed centralized governments to enhance their administrative control.

2. From an *economic* standpoint I will argue that weighing and measuring is a cornerstone among the cognitive processes involved in economic activities. Setting shared standards of weights and measures is of special importance for economic life as

systems of measurement, like the metric system, are economic instruments; they are "social knowledge" involved in practically all economic processes (from the estimation of the productive capabilities of land and industry, to problems of transaction costs and asymmetric information). The metric system became a handy instrument as an internationally accepted standard of measurement for a nascent economy of global reach.

3. From the standpoint of *science* the metric system is analyzed as an instrument appropriated by scientific groups as an exact and universal language able to aid international cooperation among experts. This view was opposed by some scientists in different countries that preferred the rationalization of national standards of measurement and by certain occupational groups that had invented or perfected their own measurement systems and saw the adoption of metric measures as a costly and unnecessary innovation. This opposition occurred also because units and techniques of measurement serve as symbols and vehicles of group identity among professionals and specialists. Also, in confrontation with the metric system were a considerable number measurement systems created *ex professo* to challenge it. The triumph of the metric system over its challengers (old and new) in scientific circles contributed greatly to its ultimate global success.

4. Finally, from the standpoint of the man on the street, the *non-experts*—those millions of ordinary people that one day woke up to the news that metric units would be from then on the only sanctioned measures for all commercial and civil exchanges and contracts—I will analyze how laypeople adapted their measurement customs and their "folk arithmetic" to the exigency of employing an utterly alien system. On the other hand, for people the act of measuring is not just a quantifying action, but a moral one as well; to

understand that a change in measuring systems also involves a transformation in the "moral economy of measurement" is therefore crucial to appreciate popular opposition to the introduction of the metric system.

This analytical strategy of studying the forms and meanings that the metric system has acquired, and the conflicts and solidarities that it had incited when it enters different social arenas emphasizes the fact that the metric system is a polyvalent object—and a device with a "promiscuous utility."[2]

The practical impossibility to observe these processes at a global scale prompted me to opt for a national comparative analysis. This scale is manageable enough to observe in detail the social life of measures (from the structural transformation of the state to the reaction of small indigenous communities), and big enough to understand the international dynamics of metrication. In other words, by studying national cases it is possible to see the local manifestations of a global process (to think globally and investigate local, so to speak), and also how local and national actors and institutions shape global processes.

This research is a comparative historical investigation of two cases to construct a meaningful historical interpretation; in this regard, this strategy differs from others in historical sociology, since it does not pretend to apply a general theory, or analyze causal regularities in history. My aim is to understand not only the development of social structures, but also the intentions and meanings of individuals and groups whose actions

[2] This follows Langdon Winner's observation that "technological objects and processes have a promiscuous utility," *The Whale and the Reactor* (Chicago: University of Chicago Press 1986), 6.

are framed by those structures. By being this a comparison and not a single study case, this dissertation wants to draw attention, in part, to particular elements of each individual case that are relevant to explain their present situation.[3]

Information was obtained, mainly, by qualitative analysis of historical data, from both primary (archival and printed) and secondary sources. More than ten archival repositories, in the United States and Mexico, were consulted over a period of five years.

By focusing on the cases of the United States and Mexico I am trying to achieve various objectives.

1) The Mexican case is useful to see what motivates a country to adopt a new measurement system, how governments manage to enforce the new system on commercial transactions and civil contracts, how social groups react to this imposition, what forms of resistance and rejection emerge in the process, and how lay people learn and appropriate the new measures.

2) The United States case helps to explain why a country decides not to adopt the metric system, how it manages the expectations and demands of groups that want its adoption, and how certain groups decide to use the system in their professional activities even if they are not required by the state to do so. Furthermore, by studying the most conspicuous national case of resistance to the worldwide process of metrication, I want to show what the circumstances that have halted its development are.

[3] On this methodological strategy see Theda Skocpol ed., *Vision and Method in Historical Sociology* (New York: Cambridge University Press, 1984), 362-374.

The selection of the case of the United States is more or less obvious because is the only Western country that has not adopted the metric system and that status is captivating by itself. But why compare it with Mexico and not France, Russia, China, Canada or whatever else? If we want to understand the expansion of the metric system beyond Europe, Mexico and the United States became important cases because Mexico was (alongside Colombia and Venezuela) the first non-European country to officially and voluntarily adopt the metric system—while the United States is the exception to the rule. If we add to this the fact that the two are neighboring countries, the comparison becomes more intriguing.

Considering the economic, technical, and scientific ascendancy of the United States over its weaker neighbor, one may imagine that it would be natural for Mexico to use the same metrological system as the United States (whichever this may be). Also, if we take into account that large scale commerce and international economic integration are two important elements of metrological unification across countries it would be "natural" for Canada, Mexico, and the United States to share the same system of measurement. From this vantage point the present situation looks rather odd, and begs further inquiry.

Comparisons between Mexico and the United States are rare, even though these neighboring countries share a long common history. Somehow, comparisons between Mexico and the United States do not look as "obvious" as the comparisons between Germany and France or Brazil and Argentina. Also, comparisons between the United States and western European countries appear as something more evident than, say, a comparison between England and Zambia. In my view there is something related to the classification of countries as developed/industrialized and underdeveloped/non-industrialized that has become an epistemological barrier, preventing us from imagining an analytical equivalence between countries placed on different sides of this classification.

When the differences and similarities between "underdeveloped" and "developed" countries are compared, usually there is a tendency to consider that the history, values, and institutions of the latter are "normal," and those of the former are deviations from that norm (or that they exist in an "immature" form). However, with metrication in Mexico and the United States, it is the American case that is highly "atypical." I consider that this inversion may help to denaturalize the American case and to consider both cases better in their own terms.

The comparison between Mexico and the United States in this dissertation will not be a chronological one (i.e. contrasting what happened in each country at the same period of time), but an analytic one (i.e. looking at the same set of social problems and actors, even though they unfold in different chronological periods). Thus, for example, while two crucial moments in the process of state formation in the United States took place in the 1770s and 1860s, in Mexico those moments occurred in the 1820s, 1880s and 1930s. There are no chronological parallelisms; nevertheless, the processes are comparable in analytical terms and they are susceptible to a sociological reading.

Summary of Chapters

Chapter one traces the patterns of the global diffusion of the metric system since its creation during the French revolution until its most recent adoption by Saint Lucia in 2000. The analysis is based on a dataset on international metrication by country specially assembled for this investigation. This represents the first truly global analysis of this process. The dataset covers all 196 countries according to the grid of national states in 2010. How and when countries adopted the metric system as their official system of measurement is explained considering geographical factors (e.g. vicinity) and historical circumstances (such as social revolutions, national unifications, foreign military imposition, colonialism, and decolonization). Moreover, the chapter underlines the significant influence of colonization in spreading the metric system outside Europe (particularly in Africa), stresses the role of Latin American countries in making the metric system a legitimate international standard during the nineteenth century, and highlights the American imprint on the seven remaining countries that have not adopted the metric system. Finally the diffusion of the metric system is compared, on the one hand, with the dissemination of other technical languages used globally today (Hindu-Arabic numerals and the international Time Zones system); and, on the other hand, it is compared with the plan of a decimal system of time reckoning, an innovation that failed to be adopted besides its numerous similarities with the metric system.

Chapter two analyses how modern nation-states took aspecial interest in the metric system as a means to establish a *monopoly on the legitimate means of measurement*. The aim of this chapter is to show that *modern nation-states need* *metrication* and that *metrication needs the states*. States need metrication because the establishment of the metric system gives them leverage to fulfill some of their essential functions: enhancing the extraction of revenue; making the population and economic resources "legible"; monopolizing symbolic capital; undermining the influence of local authorities; consolidating internal markets; sharing scientific and commercial standards with other countries; and introducing homogenizing institutions that aid the creation of a common national experience. Metrication needs the state because only modern states have shown to be effective in helping, compelling, and, if necessary, forcing populations at large (and not only some professional groups) to employ metric units; science, commerce, and industrialization alone have not been able to do this. Full metrication, in other words, requires *compulsion,* and it can only be achieved on a large scale when two actions are combined: 1) policing the employment of metric units; 2) providing populations with the intellectual and materials means to learn the metric language. The cases of the United States and Mexico are used to illustrate these ideas. The key moments for metrication in Mexico are closely linked first with the triumph of the liberals and the introduction of a new constitution in 1857; second, with the government of Porfirio Díaz and the instauration of the first effective centralized state (1880-1910); and finally, with the government of Lázaro Cárdenas, when the foundations of the post-revolutionary regime were laid (1934-1940). In the United States two key moments were the years after the war of independence, and the period of Reconstruction (1865-1877). The central difference between the Mexican and the American cases is the construction of a centralized state in the former, and a fragmented federal system where the states of the federation retained greater autonomy vis-à-vis the central government in the latter.

Chapter three deals with the problem of how economic actors in the United States and Mexico, during the nineteenth and twentieth centuries, struggled to define what standards of weights and measures would benefit them the most. Two processes in particular are analyzed in depth. First, the interactions between the metric system and monetary policy which were interweaved with the issue of establishing a "universal currency," either through the defense of already existing currencies like the Mexican silver peso (widely used in Europe, America, and China) or through the design of a newly created metric-based international currency. Second, the political battle, from 1900 to 1920, between American manufactures—congregated largely in the National Association of Manufacturers—and a loose coalition of exporters, scientists, and federal government agents over the adoption (or not) of the decimal metric system as the only legal system of weights and measures in the United States. Big American exporters financed organizations, lobbyists and information campaigns to secure the adoption of the decimal metric system (what they called a "universal language for commerce") to facilitate trade with countries from the Pacific and Latin America, and to make American companies more competitive in those markets. This effort was backed by the National Bureau of Standards and by a large number of scientists and educators. Manufacturers, on the other hand, who faced the financial burden of retooling and acquiring new equipment if metric legislation were to be passed, attacked members of Congress who supported metrication and organized vociferous campaigns in defense of what they characterized as American and Anglo-Saxon measures, traditions, language and culture under attack by a foreign-minded, pro-metric elite. Manufacturers also counterattacked the internationalistic pretensions of the metric camp by pushing the idea that the English system of weights and measures should be implanted in all the Americas as a standardized Pan-American system of measurement. In the long run, the opposition by the NAM to the metric legislations proposed during the first two decades of the twentieth century proved to be crucial in the ultimate failure of the United States to adopt the metric system.

Chapter four examines the role of scientists, intellectuals, and educators in the campaigns and implementation of the metric system in Mexico and the United States, with emphasis on their positions vis-a-vis political power. In Mexico, in the second half of the nineteenth century, scientists were in charge of important offices in the government, and had a voice in the decision making of national policies; their role in the adoption and effective introduction of the metric system was crucial. On the contrary, in the United States scientists played a more limited role in the government and their opinion on metrication was less influential. There is as well an analysis of the debates among the Mexican intelligentsia during the nineteenth century over the pertinence of adopting the metric system, with a group of influential intellectuals pushing for metrication and others arguing in favor of updating (on a scientific basis) the units of measurement inherited from the colony. The chapter also traces a portrait of a *typical* pro-metric intellectual in nineteenth-century America, the educator and celebrated librarian Melvil Dewey, the founder of the first voluntary organization devoted to impulse metrication in the country—the American Metric Bureau. Finally there is an analysis of the figures Hebert Spencer and Lord Kelvin, whose debate over metrication at the turn of the century reshaped the content of the discussions over metrological reform on both sides of the Atlantic.

Chapter five deals with how people received, learned, and appropriated the metric system for their everyday lives. Who accepted the new measures voluntarily and who had to be coerced into it? What forms of opposition appeared? Particular attention is given to a peasant revolt against the introduction of the metric system in the Mexican southern state of Oaxaca, when more than one thousand Indigenous Mexicans stormed the town of Juquila and killed the local authorities. This rebellion is then compared with a similar event in Brazil, known as the "*Quebra-Quilo* revolt." The chapter frames the actions of the rebels as part of a larger tradition of uprisings against changes in the systems of measurement, and interprets these actions as guided by a "moral economy of measurement." In Mexico the reception to the metric system was slow and difficult; people did not oppose metrication openly, but a sort of "passive resistance" was very effective; the public at large, small merchants, and some local authorities simply ignored the regulations that banned traditional measures and kept using them (especially in rural areas).

2. FOR A HISTORICAL SOCIOLOGY OF KNOWLEDGE

As I stated earlier, this dissertation is conceived as a historically-grounded investigation into large-scale processes of social cognition and as such it aims to contribute to the development of a *historical sociology of knowledge*.

As it is well known, the sociology of knowledge studies the mutual interaction between knowledge and society, where "knowledge," as Robert Merton pointed out, should be broadly understood as "virtually the entire gamut of cultural products (ideas, ideologies, juristic and ethical beliefs, philosophy, science, technology)."[4] There are multiple theoretical and methodological versions of how that relationship between forms of thinking and social structure ought to be analyzed, but a common denominator in all efforts is the stress on the idea that knowledge is—at least partly—a social product, instead of a self-sufficient entity or the creation of isolated individuals. This means that to have a thorough understanding of how people know things, it is necessary to consider the social relations in which they are involved, the social structures that constrain their actions, and the intellectual and material resources that the societies they live in put at their disposal to organize their thought. Knowledge, in this sense, is the *act of knowing,* an action performed by individuals who belong to particular social settings and live in specific historical conditions.

What a *historical sociology of knowledge* adds to this common definition is that it not only considers that individuals participate in the knowledge and knowing conditions of the social groups to which they belong (i.e. it sees knowledge as a collective enterprise), but it also emphasizes the idea that individuals and groups acquire knowledge through a cognitive wealth that they received from previous generations. As Karl Mannheim put it, "strictly speaking it is incorrect to say that the single individual thinks.

[4] Robert K. Merton, "The Sociology of Knowledge," in *Social Theory and Social Structure* (New York: The Free Press, 1968), 510.

Rather it is more correct to insist that he participates in thinking further what other men have thought before him. He finds himself in an inherited situation with patterns of thought which are appropriate to this situation and attempts to elaborate further the inherited modes of response or to substitute others for them in order to deal more adequately with the new challenges which have arisen out of the shifts and changes in his situation."[5] This problem of the historical dimension of social cognition is certainly not new, from Comte's "law of three stages"[6] to Randall Collins' "global theory of intellectual change"[7] sociologists have built multiple schemes to come to grips with these phenomena.

The general problem I am interested in here is how social groups and institutions create, distribute, control, monopolize, and appropriate knowledge through time. This has to do with *how social stocks of knowledge are constituted, accumulated, retained, and transmitted from generation to generation*.

These issues have been tackled from different angles, with two overall perspectives dominating their theoretical contributions.

On the one hand, there are macro-historical sociological outlooks that give priority to long-term historical developments of accumulation of experiences and the formation of social funds of knowledge. Their time framework era millennia; their units

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[5] Karl Mannheim, *Ideology and Utopia: An Introduction to the Sociology of Knowledge* (New York: Harcourt, 1985), 3. Emphasis added.

[6] Auguste Comte, *Discurso sobre el espíritu positivo* (Madrid: Alianza, 1997), 17-34.

[7] Randall Collins, *The Sociology of Philosophies: A Global Theory of Intellectual Change* (Cambridge: Harvard University Press, 1998).

of analysis are chains of generations—which may include "humanity as a whole." Representatives of this theoretical standpoint (it can hardly be defined as a school or paradigm) are Durkheim's sociological theory of knowledge and Norbert Elias' theory of symbol.[8]

On the other hand, there are the micro-sociological perspectives that focus on the biographical accumulation of experience, its sedimentation into a subjective stock of knowledge, and on the linkage between the individual and the social funds of knowledge at his or her disposal. Their time framework is the human being life-span (i.e. the individual's biography), and their unit of analysis are individuals in their everyday life. This line of research sprung from the phenomenological tradition in the sociology of knowledge, as developed by Alfred Schutz, Thomas Luckmann, and Peter Berger.[9]

Between these two theoretical outlooks there is an obvious breach, a missing *meso-historical level* able to analyze how social funds of knowledge are shaped and transform by political, economic, and intellectual conflicts and alliances among social groups and institutions in middle range historical spans. The time framework of this level would be centuries, its units of analysis social institutions and organizations. This kind of analysis, despite not being fully developed yet, can be related to the work of historians

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[8] Emile Durkheim, *The Elementary Forms of Religious Life* (New York: Free Press, 1995), 8-19, 433-447; Norbert Elias' historical sociology of knowledge was developed in *The Symbol Theory* (London: Sage Publications, 1991); *Time: An Essay* (Oxford: Blackwell, 1992); and *Involvement and Detachment* (New York: Blackwell, 1987).

[9] Alfred Schutz and Thomas Luckmann, *The Structures of the Life-World* (Evanston: Northwestern University Press, 1973) 243-331; Thomas Luckmann, "Individual Action and Social Knowledge," in *The Analysis of Action: Recent Theoretical and Empirical Advances*, ed. M. von Cranach and R. Harré (Cambridge: Cambridge University Press, 1982), 247-265; Peter Berger and Thomas Luckmann, *The Social Construction of Reality* (New York: Anchor, 1966), 41-46.

like Fritz Ringer and Peter Burke—who have explored the idea of a *social history of knowledge*.[10] This dissertation is an attempt at work in this area; and aims to provide a much needed empirical study on the long-term historical process of distribution, appropriation, and monopolization of knowledge.

The Problem of the "Spread of Understanding"

In a paper from 1922 the forefather of the history of science, George Sarton, drew attention to what he called "the spread of understanding," and through a series of historical vignettes he tried to illustrate the complications in disseminating scientific progress. Some of those vignettes were dedicated to decimal notation, Hindu-Arabic numerals, and their practical applications. There Sarton posted some stimulating observations:

> The case [of the dissemination of Hindu-Arabic numerals] is interesting because the new decimal system was a time- and labor-saving invention of the first magnitude. The Hindus had made to mankind a gift of inestimable value. No strings of any kind were attached to it, nor was the suggested improvement entangled with any sort of religious and or philosophic ideas. Those proposing to use the new numerals were not expected to make nay disavowal or concessions; nor could their feelings be hurt in any way. They were asked simply to exchange a bad tool for a good one. [… However] more than a millennium had elapsed between the discovery and its general acceptance […].

10 Fritz Ringer, "The Intellectual Field: Intellectual History, and the Sociology of Knowledge," in *Towards a Social History of Knowledge* (New York: Berghahn, 2000) 3-25; Peter Burke, *A Social History of Knowledge: From Gutenberg to Diderot* (Cambridge: Polity, 2000). Some interesting comments by Burke about the principles underlining his book and its upcoming second volume can be seen in the blog of the journal *Theory, Culture and Society:* "Writing the Social History of Knowledge," http://theoryculturesociety.blogspot.com/2010/12/peter-burke-on-writing-social-history.html, accessed March 10, 2011.

> Mountains and seas and even desert plains are smaller obstacles to the diffusion of ideas than the unreasonable obstinacy of man. The main barriers to overcome are not outside, but inside the brain.[11]

Sarton then moved to the figure of Simon Stevin—who developed a system to express decimal fractions—and noted that Stevin realized that one of the "logical consequences" of the introduction of a decimal system of numbers and fractions would lead to a decimal system of weights and measures and that the adoption of one was not truly complete without the adoption of the other—"to measure according to one system and to count according to another destroyed the economy of both." Sarton described the invention of the metric system during the French Revolution as the embodiment of Stevin's vision. Assessing the diffusion of the metric system Sarton observed that

> During the last century [the metric system] spread all over the world, except, strangely enough in the Anglo-Saxon countries where it met—and still meets—with a resistance, which is stronger in that it is irrational. [… There] are still many English and American apostles, full or learning, who will prove to everybody who will listen that their incongruous sets of weights, measures and moneys are much more convenient than the metric system! How can they do it? I really don't know, but they do it with a fervor only equalled by the paradoxical absurdity of their plea.[12]

These comments and questions are relevant and intriguing. But Sarton's harsh statements on the "unreasonable obstinacy of man" and the "absurdity" of British and American metric opponents show little sensitivity to some relevant issues that may help

[11] George Sarton, "The Spread of Understanding," in *The Life of Science: Essays in the History of Civilization* (Bloomington: Indiana University Press, 1960), 7.

[12] Sarton, "The Spread of Understanding," 11-12.

to explain the particular form that the spread of human understanding took in different historical moments and under diverse social conditions. Can we use sociology to address some of the issues riced by Sarton from a different perspective? As it happens, at the time as he was writing this article, in Germany a group of scholars started to develop some sociological theories and methods to deal with similar problems.

Social Distribution and Monopoly of Knowledge

In the 1920s Max Scheler, widely considered as one of the founders of the sociology of knowledge, claimed that

> The sociology of knowledge must trace the laws and rhythms by which knowledge of those at the top of the society, the intellectual elites, filters downward and is distributed over time among various groups and strata. This discipline must, therefore, also understand how such knowledge is socially regulated, partially through the institutions that disseminate it, such as schools and the press, and partially through the social barriers that restrict it, such as secrets, indexes, censorship, and prohibitions that forbid particular castes, estates, or classes to acquire certain kinds of knowledge.[13]

Despite the fact that Scheler never developed a solid theory on the creation, circulation, and regulation of knowledge, he was one of the initial links in a long chain of sociologists who had tried to elucidate these problems. Broadly speaking, the theories that have studied how knowledge is distributed in society and how some social groups monopolize it emphasize three aspects: (1) *every society has a collective stock of*

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[13] Max Scheler, "Formal Problems of the Sociology of Knowledge," in *On Feeling, Knowing, and Valuing* (Chicago: The University of Chicago Press, 1992), 204.

knowledge—knowledge of many kinds: science, ideology, techniques, and so forth. That knowledge, however, (2) *is not equally distributed* among all individuals and groups; people from different professions, classes, gender, generations, etcetera, have access to distinctive sections of that collective stock of knowledge (e.g., our society knows how to bake bread, but just a small group of people, like bakers, have the information and skills to actually do it). And (3) *the distribution of knowledge is closely related to power;* thus, not all social groups have the same opportunities to acquire "privileged" types of knowledge—like science or the high arts.

Possibly the first explicit theorization of the social distribution of knowledge appeared in Alfred Schutz's essay "The Well-Informed Citizen." There Schutz pointed out that "knowledge is socially distributed and the mechanism of this distribution can be made the subject matter of a sociological discipline."[14] All societies possess a stock of knowledge; in modern societies this stock—made by practical experiences, science, and technology—is accessible to the members of a society; however, "this stock of knowledge is not integrated. It consists of a mere juxtaposition of more or less coherent systems of knowledge which themselves are neither coherent nor even compatible with one another."[15] Specialized systems of knowledge, Schutz said, are distant from one another.

[14] Alfred Schutz, "The Well-Informed Citizen: An Essay on the Social Distribution of Knowledge," in *Collected Papers II* (The Hague: Martin Nijhoff, 1976), 121.

[15] Schutz, "The Well-Informed Citizen," 120.

Individuals find in their society some basic knowledge that helps them to act in the world and establish relations among themselves. This was described by Scheler with the term "relatively natural worldview" (a knowledge that all members of a group take for granted). But Schutz was not satisfied with the scope of the term: "Useful as this concept is in many respects, it is clear that all the members of an in-group do not accept the same sector of the world as granted beyond question and that each of them selects different elements of it as an object of further inquiry. Knowledge is socially distributed."[16] Sadly—and in spite of his contribution to defining the problem of the social distribution of knowledge, and of his suggestive ideas—Schutz did not develop a finished sociological model of the social distribution of knowledge.

Karl Mannheim argued that the social distribution and the monopoly of knowledge is a product of competition among social groups. A key element in Mannheim's explanation of the social determination of knowledge was the notion that there are conflict and competition among groups. Mannheim argued that competition plays a "co-determinant" role in intellectual life. Different interpretations of reality, thus, have to be related with power struggles among social groups. Mannheim defined four types of social processes that generate interpretations of reality: 1) the spontaneous cooperation between individuals and groups, 2) the monopoly-position of one particular

[16] Schutz, "The Well-Informed Citizen," 121.

group, 3) the competition of many groups, and 4) a concentration around one point of view of a number of formerly competing groups.[17]

The monopoly-position of one group consists in an interpretation of the world shared by an entire society that is based on the position of a single group, typically a closed status group. The group that possesses the monopoly can secure its position by intellectual and non-intellectual means. To endure this monopoly-position requires social structural stability.[18]

Mannheim considered that a characteristic feature of modern societies is the multiplicity of ways of thinking. But that was not a problem in periods of social stability when the unity of the worldview was guaranteed. In those static periods the special groups that provide interpretations of the world are likely to acquire a predominant status in society, and those groups monopolize the right to preach, teach and make interpretations of the world.[19] However, the social conditions that allow the existence of this monopoly can change. Social mobility is one of the elements that can destroy the presence of a singular worldview. Another element for the disappearance of monopolist worldviews is the destruction of the social position of the group that produces it.[20]

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[17] Karl Mannheim, "Competition as Cultural Phenomenon," in *From Karl Mannheim* (New York: Oxford University Press, 1971), 230.

[18] Mannheim, "Competition as Cultural Phenomenon," 233-234.

[19] Mannheim, *Ideology and Utopia*, 10.

[20] "From a sociological point of view the decisive fact of modern times, in contrast with the situation during the Middle Ages, is that [the] monopoly of the ecclesiastical interpretation of the world which was held by the priestly caste is broken, and in the place of a closed and organized stratum of intellectuals, a free intelligentsia has arisen," Mannheim, *Ideology and Utopia,* 11. A related but more punctual investigation on this problem can be seen in Ginzburg's work on how the Reformation and the invention of the printing press changed people's worldview even in rural villages—people like Menocchio, a sixteenth-century

Norbert Elias—student of Mannheim in Germany in the 1930s—followed some of these ideas emphasizing that the sociological analysis of knowledge has to be linked with the problem of power. Power, according to Elias, is not something that can be possessed (i.e., it is not an object); power is a social relationship characterized by the fact that a group or an individual keeps or monopolizes what other persons or groups need. What is monopolized can vary, and Elias denied Marx's assumption that the monopoly of economic means represents the most important—or exclusive—element needed to control a society.

Elias' idea was that there are several "sources of power" in society. What Marx failed to recognize, Elias said, was the existence of other equally important sources of power; Elias added that we have to consider at least another three: the control of violence, the capacity for self-restraint, and knowledge. All these four functions are equally important:

> With regard to the distribution of power in a society one can say that monopolization of the means of orientation, that is of knowledge, […] plays no less a part as a source of power than the monopolization of the means of production. Neither the social function of violence management and control nor that of knowledge transmission and acquisition can be simply reduced to, and explained in terms of, the economic functions of a society.[21]

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miller from the Friuli, who was judged and executed by the Inquisition. Ginzburg notes that Menocchio's history was the product of the end of the monopoly over the written word due to modern technologies of printing and the subsequent accessibility to printed materials by a wider population, Carlo Ginzburg, *The Cheese and the Worms* (New York: Penguin, 1982), 58-60.

[21] Norbert Elias, "The Retreat of Sociologists into the Present," in *Modern German Sociology,* ed. Meja, Misgeld, and Stehe (New York: Columbia University Press, 1987), 156. Elias proposed what may be called a "pluricausal" theory of power against the "monocausal" conception of Marxism.

The monopoly of knowledge provides power because human groups cannot survive without knowledge—in the same way as they need food or protection from violence to stay alive: "Human beings cannot survive if they cannot place events by giving them a name, by fitting them into their fund of communal symbols."[22]

Mannheim and Elias designed some models to explain the social distribution of knowledge as a result of group and class struggle. However, they did not give us many clues about how and why all the members of a single society participate in a single body of knowledge. On the other hand, Scheler and Schutz explained the social origins and consequences of this common stock of knowledge; nonetheless, social conflict played a very poor role in their sociological reflections. Peter Berger and Thomas Luckmann accepted both of these principles. In their own words: "The important principle for our general considerations is that the relationship between knowledge and its social base is a dialectical one, that is, knowledge is a social product *and* knowledge is a factor in social change."[23] It was in this context that Berger and Luckmann discussed the two themes that interest us here: the social distribution of knowledge and the monopoly of knowledge.

The basic assumption of Berger and Luckmann was that the distribution of roles in society implies a social distribution of knowledge: roles are mediators of particular sectors of the social stock of knowledge. This stock is thus divided into what is generally relevant and what is important only for certain roles. Accumulation of knowledge and the

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[22] Elias, "The Retreat of Sociologists into the Present," 163.

[23] Peter Berger and Thomas Luckmann, *The Social Construction of Reality* (New York: Anchor Books, 1989), 87.

division of labor produce a specialized knowledge that is only useful for some specific activities. Thus it is necessary that some individuals become specialists, and they administrate the segment of the stock of knowledge assigned to them.

The second topic of *The Social Construction of Reality* that interests us here is the relation between the monopoly of knowledge and the social organization for the maintenance of symbolic universes. By "symbolic universes" Berger and Luckmann mean bodies of theoretical tradition that integrate different regions of meaning and create a coherent explanation for different social institutions; they also help to organize and define what reality is for a society. And these universes need a social organization in order to prevail and last—and here the problem of power appears: "power in society includes the power to determine decisive socialization processes and, therefore, the power *to produce* reality."[24] Definitions of reality, Berger and Luckmann argued, can be imposed by the use of force, and this is the case especially when different groups of specialists (supported by a bigger social stratum) are competing to dictate which symbolic universe is predominant.

The possibility that one group monopolizes an undisputed definition of reality and a single symbolic universe also exists—and this actually happened in many premodern societies. Such a situation requires the support of a unified structure of power. "Monopolistic situations of this kind presuppose a high degree of social-structural stability, and are themselves structurally stabilizing. Traditional definitions of reality

[24] Berger and Luckmann, *The Social Construction of Reality,* 119.

inhibit social change. Controversy, breakdown in the taken-for-granted acceptance of the monopoly accelerates social change."[25] Because of this there is a strong link between the group with power and the individuals that help to maintain monopolistic traditions of universe-maintenance.

With these theoretical principles in the background we will see how knowledge, as Mannheim stressed it, is shaped by social groups that are in continuous competition and conflict. The metric system was appropriated by different groups and institutions that struggled to regulate, control, and—if possible—monopolize the establishment, management, and use of systems of weights and measures in general, and the metric system in particular. The history of the decimal metric system shows how the dissemination, adoption, and appropriation of systems of knowledge that became unquestioned features of modern and global funds of knowledge were shaped by conflict, negotiation, conquest, and domination. These conflicts took place in many different social arenas, among numerous social groups, and at diverse societal levels; conflicts among different economic interests, styles of thinking, professional practices, political powers, forms of expertise, state and civil society, conquerors and the conquered—that is to say that in the social accumulation of knowledge, like in the primitive accumulation of capital, a large part was played by "conquest, enslavement, robbery, murder, force."[26]

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[25] Berger and Luckmann, *The Social Construction of Reality,* 122-123.

[26] Karl Marx, *Capital: A Critique of Political Economy* (New York: Penguin, 1990), 874 (the quote refers to the "social the primitive accumulation of capital").

3. SOCIOLOGY OF MEASUREMENT

According to the *Oxford English Dictionary* measurement is “The action or an act of measuring or calculating a length, quantity, value, etc.” or “A dimension ascertained by measuring; a magnitude, quantity, or extent calculated by the application of an instrument or device marked in standard units.”[27] So defined, measurement looks like an uncomplicated action, but, as I will show, on the basis of this simple act rest almost all economic calculations and estimations, the possibility to communicate scientific results, the political administration of land and resources and the apprehension of the physical dimensions of the objects in the surrounding world (including our own bodies). Also, I will demonstrate that the establishment of “standard units,” an essential part for any socially agreed measurement, is a contentious process.

Measurement is then a controversial and ubiquitous social process present in an infinity of ordinary but necessary actions. As John Quincy Adams pointed out

> Weights and measures may be ranked among the necessaries of life to every individual of human society. They enter into economical arrangement and daily concerns of every family. They are necessary to every occupation of human industry, to the distribution and security of every species of property, to every transaction of trade in commerce, to the labors of the husbandman, to the ingenuity of the artificer, to the studies of the philosopher, to the reaches of the antiquarian, to the navigation of the mariner and the marches of the soldier; to all the exchanges of peace and all the operations of war. The knowledge of them, as an established use, is among the first elements of education and is oft-learnt by those who learn nothing else, not even to read and write. This knowledge is

[27] “Measurement,” *Oxford English Dictionary,* Third edition, http://www.oed.com/view/Entry/115513, accessed June 12, 2011.

> riveted in the memory by the habitual application of it to the employments of men throughout life.[28]

Measures are everywhere. They are imperceptible to our eyes. The deep cultural significance of measures can be appreciated precisely in this *social invisibility.* Clifford Geertz argues that when the anthropologist cannot find the meaning of a practice of another culture, the anthropologist is at the door of a nucleus of meaning of that culture.[29] To clarify those *obscure* practices is an effective way of "entering" into that culture. However, other social scientists have to struggle with the opposite problem; when they study not an alien culture, but their own, they have to find the core of their culture in those practices and institutions that are *invisible* to them and the fellow members of their society. Those practices and institutions are not perceptible because they are *taken for granted*. In the words of Ken Alder:

> Measurement is one of our most ordinary actions. We speak its language whenever we exchange precise information or trade objects with exactitude. This very ubiquity, makes measurement invisible. To do their job, standards most operate as a set of shared assumptions, the unexamined background against which we strike agreements and make distinctions. So it is not surprising that we take measurement for granted and consider it banal. Yet the use a society makes of its measures express its sense of fair dealing. […] Our methods of measurement define who we are and what we value.[30]

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28 John Quincy Adams, *Report of the Secretary of State, upon Weights and Measures, Prepared in Obedience to a Resolution of the House of Representatives of the fourteenth of December 1819* (Washington: Gales & Seaton, 1821), 119-120.

29 Clifford Geertz, "Thick Description: Toward an Interpretative Theory of Culture," in *The Interpretation of Cultures* (New York: Basic Books, 2000), 3-30.

30 Ken Alder. *The Measure of all Things* (New York: The Free Press, 2002), 1-2.

At first sight measurement is not a social problem precisely because it is deeply cultural. Measures are omnipresent. We use them constantly in everyday life. But because we take their presence for granted, they are imperceptible to our eyes. In order to function effectively standards of measure have to work as unquestioned assumptions.

Measurement is a key element in numerous social interactions, but it has been inadequately studied. It is not easy to realize that the measures we use to organize and quantify the world have a history, nor that this history is filled with social meanings. So, it is the work of sociology to reveal the *thickness* of the systems of measurement. Also, the historically oriented sociologist ought to describe *how a modern system of measurement like the metric system, which was completely alien to people two centuries ago, came to be part of our relatively natural worldview.*

Historians and anthropologists have studied measurement primarily because they frequently have to deal, in the field or archive, with customary or non-metric systems of weights and measures. Some of them have had the curiosity to understand those measures as an integral part of the social worlds they are studying. So, it is not enough to translate local measures into their metric equivalences; it is necessary to comprehend weights and measures as part of a web of social symbols and interactions. Weights and measures are not different, in this sense, from art, science, religion, common sense, and other languages and systems of thinking.

Measurement, Categorization, and Cognition

In a way, measurement could be considered part of the problem of the classification of reality, a topic explored sociologically by Emile Durkheim and Marcel Mauss.[31] One of the basic ideas in Durkheim's and Mauss' argument is that the classificatory function—the ability to categorize and establish hierarchies of things and events about the world—is a social institution, instead of an inherent mental faculty of individuals.[32] Following this thesis, Durkheim and Mauss insisted that the categories of thinking are socially constructed.[33]

The Durkheimian-Maussian analysis of classification emphasizes that categories (such as space, time, gender, number, cause, class, etcetera) act as a framework that shapes the intellect and makes thinking possible. It accepts Kant's assertion that categories, and not individual experience, come first; but it rejects the supposition that those categories have a metaphysical origin. For Durkheim and Mauss categories exist before experience because they are exterior and previous to individuals: categories are historical products, social facts.[34] Categories are imposed over individuals by society

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[31] Emile Durkheim and Marcel Mauss. *Primitive Classification* (Chicago: The University of Chicago Press: 1963).

[32] Durkheim and Mauss, *Primitive Classification,* 3-9.

[33] As Bowker and Star put it, "To classify is human," Geoffrey C. Bowker and Susan Leigh Star, *Sorting Things Out: Classification and its Consequences* (Cambridge: The MIT Press, 1999), 1. At some extend, Bowker and Star revitalize the ideas of Durkheim and Mauss, even though they expand considerably the richness of the consequences of classification for social life. This work is also relevant because in it the authors relate classification with standardization, both topics relevant for the problem of modern systems of measurement.

[34] Durkheim, *The Elementary Forms of Religious Life,* 8-9.

because the group produces an intellectual and moral uniformity, a "logical consensus."[35] Society provides individuals with the means (concepts, categories, and accumulated experience) to think, to know, and to express their minds. However, individuals have to think within the logical framework imposed by society. In this way, individuals organize the world (time, space, and so forth) in the same manner as other members of their society. The same could be said about measurement; individuals have to quantify the world using the weights and measures accepted by their groups.

Curiously, in spite of the fact that Durkheim and Mauss based their own theory on Kant's theory of categories, they did not consider explicitly the Kantian category of *quantity*. Durkheim showed in his works on religion how time, space, and causality can be explained sociologically because they are collectively and historically constructed; but he did not gave us clues about a possible *sociological analysis of the category of quantity*.

Measuring is one of the most basic forms of quantification, and also an activity that is collectively determined. It is previous and exterior to individuals, and it is organized through collective instruments and social conventions. Also, like any other social fact, measurement implies a logic that society coercively imposes over its members. One of the most important tasks to understand the social and cultural roots of measurement is then to clarify the *cognitive dimension involved in measuring processes*.[36]

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[35] Durkheim, *The Elementary Forms of Religious Life,* 16.

[36] Anthropological works have clarified some of these problems. See for example, A. I. Hallowell, "Some Psychological Aspects of Measurement among the Saulteaux," *American Anthropologist* 44 (1942): 62-77;

Any system of measurement presupposes, among other things, a certain degree of mathematical knowledge present in a given society and particular economic institutions. As Thomas Crump argues,

> Generally, the process of constructing a measurable continuum is only mastered at an advance stage of cognitive development. Measurement of quantity is an operational use of number, whose function must be defined in economic terms. Not every economy needs this function, because the need for it is determined by the existence of other socioeconomic institutions.[37]

Systems of measurement are linked to the mathematical abilities of the members of a given society. As Benjamin Whorf showed, European languages can express some forms of plurality, numeration, and quantity in a more abstract way than other languages, like Hopi.[38] The sociological analysis of measures has to be related to the historical evolution of the human capacity of counting, and quantifying, on the one hand; and with the creation, accumulation, and distribution of knowledge, on the other. In this sense, since measurement implies quantification, the history of measurement is closely related to the history of mathematical abilities. A system of measurement of a given society is always subordinated to the arithmetical capabilities of its members.

C. R. Hallpike, "Number, Measurement, Dimensional Analysis, and Conservation," in *The Foundations of Primitive Thought* (Oxford: Clarendon Press, 1979), 236-279.

[37] Crump, *The Anthropology of Numbers,* 72.

[38] Benfamin Lee Whorf, *Language, Thought, and Reality* (Cambridge: Massachusetts Institute of Technology, 1956), 139-142.

The Metric System

The *Encyclopædia Britannica* defines the decimal metric system as an "international decimal system of weights and measures, based on the metre for length and the kilogram for mass, that was adopted in France in 1795 and is now used officially in almost all countries."[39] Renamed in 1960 as "International System of Units," the metric system, like so many other scientific and technical languages, codes, and inventions, appears at first sight to be an innocuous device, a dry, well-defined standard devoid of meaning, and functional for a lonely propose, to gauge the length, volume, and mass of objects.

However, as Marx's table that at first sight appears as an "extremely obvious" and "trivial thing" but that "not only stands with its feet on the ground, but, in relation to all other commodities, stands on its head, and evolves out of its wooden brain grotesque ideas, far more wonderful than if it were to begin dancing of its own free will,"[40] so we will see that once the metric system enters social life, it is transformed into an entity entrenched in deep and mutable chains of meaning; an instrument whose mere measuring capabilities became unimportant and its economic and political competencies turn into mighty weapons; a language appreciated not only for its scientific elegance, but that is praised—or vilified—for its nationalistic, ideological, and religious connotations.

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[39] "Metric system," *Encyclopædia Britannica Online,* http://original.search.eb.com/eb/article-9052355, accessed October 15, 2010.

[40] Marx, *Capital*, 163-164.

What is the metric system? It is of course a system of measurement, which means several things: a *language* (in terms of an interrelated vocabulary, verbal and mathematical), a series of *standards* (both in terms of socially agreed definitions and objects in which those definitions are materialized), and a set of socially sanctioned *practices* (about who, when, and how the units, standards, and instruments of measurement should be used).

The cognitive elements involved in measurement are important for us to be able to comprehend why it is so difficult to change from one system of measures to another, like those changes undertaken in every country that has adopted the metric system. These changes have been slow and painful, among other things because people usually do not want that substitution, and do not feel it is necessary or useful.[41] I will go into many details about these problems in the subsequent chapters, but just as an illustration I can mention here that part of the difficulties in accepting the new system was its decimal character (i.e. based on the number ten). Pre-metric systems are based typically on twelve (or in a combination of twelve, sixteen, and sixty, as can be seen in the division of the day in two dozens of hour, and the division of the hour in sixty parts). This duodecimal systems offer multiple advantages for people with no mathematical training, because it is simple to know how much is the half of a dozen (six), and the half of the half (three), and it is easy to determine the third part of a dozen (four). On the other hand, in decimal systems it is simple to calculate the half of ten (five), but it is rather complicated to

[41] Some cases of this process can be seen in Witold Kula, *Men and Measures* (Princeton: Princeton University Press, 1986), 267-288.

determine how much is a quarter (2.5), or third (3.3). These elemental operations were not so simple for people, since only well educated people were trained to use the decimal point.

As John Heilbron points out, one reason for this difficulty is that a change in the systems of measurement "alters the expected relationship between numbers and experience. […] It is very hard for one not bread to it to say naturally and with conviction that 22 degrees is a pleasant temperature for a room or that the basketball player is 2.3 meters tall. It takes a generation at least for the native speakers in one set of units to be replaced by the native speakers of another."[42] An interesting reminder that measurement standards are both physical and mental.

The Metric System as Object of Study in Sociology and History

Weights and measures, contrary to what has happened with related topics like time and money, has received little attention. And even if it is possible to find mentions to the problem of measurement in important sociological works, they are more insights and marginal notes than systematic explorations. Let's take a look.

In the very first page of chapter one of *Capital,* Marx noted that the discovery of "the *invention of socially recognized standards of measurement* for the quantities of … useful objects" is "the work of history." Moreover, "the diversity of the measures for commodities arises in part from the diverse nature of the objects to be measured and in

[42]John L. Heilbron, "The Politics of the Meter Stick," *American Journal of Physics* 57 (1989): 992.

part from convention."[43] It is somewhat puzzling that this assertion at the beginning of one of the most influential books of the last two centuries has prompted so little interest among historians and social scientists to study weights and measures within the framework of Marxist theory.

Engels, refereeing without an explicit mention to the metric system, made a brief but interesting observation on the context of social and economic reforms in which the metric system had been introduced in Germany after 1868:

> Speaking positively, the abolition of feudalism means the introduction of bourgeois conditions. In the measure as the privileges of the nobility fall, legislation becomes more and more bourgeois. […] The government reforms the laws […] in the interests of the bourgeoisie; it removes the impediments to industry emanating from the multiplicity of small states; *it creates unity of coinage, of measures and weights;* it gives freedom of trade; it grants the freedom of movement; it puts the working power of Germany at the unlimited disposal of capital; it creates favorable conditions for trade and speculation.[44]

Later in the dissertation we will see how programs of state-sponsored reforms to remove the impediments of capitalism were also very important in other countries as well and how the metric system became an integral part of those plans.

In his well-known "Preface" to the *Essays on the Sociology of Religion,* Max Weber offered some insights on the large scale historical significance of the arithmetical system that is behind the metric system. Calculation in decimal notation and algebra, Weber noted, came from India, "but it was only made use of by developing capitalism in

[43] Marx, *Capital*, 125-126. Emphasis added.

[44] Engels "Suplement to the preface of 1870 for *The peasant war in Germany,*" in *Karl Marx, Frederick Engels: Collected Works,* vol. 23 (New York: International Publishers, 1975), 629. Emphasis added.

the West, while in India it led to no modern arithmetic or book-keeping." For Weber, the technical use of scientific knowledge was encouraged in part by economic conditions, but ultimately by the particular social structure in the Occident, and he asked "from *what* parts of that structure was it derived, since not all of them have been of equal importance?"[45] This question—that is still waiting for answers—may be pertinent in the understanding of the historical development of the metric system within a larger context, but Weber himself never made that connection.

To the best of my knowledge, Auguste Comte and Herbert Spencer were the only classic sociologists who wrote explicitly about the metric system. In his *Course of Positive Philosophy,* written during the years when the metric system was being reintroduced in France,[46] Comte highly praised the system and considered its diffusion as an example of the beneficial influence of science in society and prognosticated its adoption by all civilized nations. As he put it:

> Apart from its obvious immediate utility, this memorable intervention of true speculative thought in the systematization of a department of human relations in which it seemed as first to have no part, may well presage the vast advantages which modern life may hereafter derive, in so many other respects, from a judicious rationalization of its most

[45] Max Weber, *The Protestant Ethic and the Spirit of Capitalism* (London: Routledge, 2001), xxxvii-xxxviii.

[46] From 1812 to 1837 there was an impasse in the use of the metric system in France, starting when Napoleon implemented a compromise between the metric and customary measures with the so called *mesures uselles*. The metric system was reintroduced as the exclusive and mandatory system during the reign of Louis Philippe.

practical aspects, once the influence of science has become fittingly widespread and has sufficiently permeated all sections of the economy of our revivified societies.[47]

I have not found any open connection between Comte's admiration for the metric system and the design of his "Positivist Calendar," but as a matter of speculation it sounds plausible to say that he saw both laying on the same principles.[48]

The case of Hebert Spencer is the most important of all, for one, he was the one who wrote most extensively about the issue, but more importantly because his writings and political activism influenced the course of metrication itself—mainly in England and the United States. In 1896, while the British Parliament was discussing the adoption of the metric system, Spencer published a series of articles strongly opposing the idea of adopting it.[49] Spencer argued that traditional systems of measurement had existed for centuries, and that there is a very good reason for this: the divisibility of duodecimal (twelve-based) and hexadecimal (sixty-based) systems made them more suitable for everyday activities than a decimal system; the great difficulties of effectively imposing the metric system of measures and coinage in those countries where it was adopted was, for him, proof of that. By getting rid of the traditional measures, Spencer claimed, we

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[47] Quoted in Luce Langevin, "The Introduction of the Metric System: The First Example of Scientific Rationalization by Society," *Impact of Science on Society* 11 (1961): 95. This paragraph comes from a larger passage in Comte's *Cours de philosophie positive 6: Le complément de la philosophie sociale et les conclusions générales* (Paris: Baillière, 1864), 373-374. See also *La sociologie par Auguste Comte: Résumé par Émile Rigolage* (Paris: Félix Alcan, 1897), 360, where a similar syntesis of this idea is given: "L'influence sociale de la science recevait alors de notables accroissments. Au milieu de plus grandes orages politiques surgissaient d'importants établissments destinés à propager l'instruction scientifique. La France instituait l'admirable système métrique, qui sera un jour adopté par tous les peuples civilisés."

[48] On Comte's positivist calendar see Auguste Comte, *Auguste Comte and Positivism: The Essential Writings* (New York: Harper, 1975), 466-476.

[49] These articles can be found in Herbert Spencer, "Against the Metric System," in *Various Fragments* (New York: D. Appleton and Company, 1914), 142-171.

would lose the wisdom of "the early man of science and the modern men of practice" (I will come back to Spencer's anti-metric crusade in chapter four).

Despite the insights in the writings of classic sociologists, there is not enough density or depth in them to elucidate how a sociological analysis of weights and measures may look. Probably the first significant breakthrough highlighting a more complete sketch of a sociology of measurement came with Otis Dudley Duncan's *Notes on Social Measurement*.[50] And even if his treatment was more an assorted mix of observations than a program or systematization, Duncan raised some crucial issues. For one, he started to discern what kind of benefits such a sociological topic of enquiry may bring. As he put it, "A sociology of measurement, allied with an expanded historical metrology, is needed not less for the improvement of measurement techniques than for understanding the role of quantification in society." [51] More broadly, Duncan provided an entrance point to tackle the issue of weights and measures from a legitimate sociological perspective:

> Our physical dimensions and techniques for measuring them are social constructs that were invented to solve social problems, and our systems of physical units have evolved thought a complex social process that invites investigation by students of social change, class conflict, social movements, bureaucratization, and the sociology of knowledge, as is suggested by observations on the origin and diffusion of the metric system.
>
> […]
>
> The obligate symbiosis of sovereignty and mensuration, the bureaucratization of science consequent upon its opting for measurement standardization, the resilience of custom, the

[50] Otis Dudley Duncan. *Notes on Social Measurement* (New York, Russell Sage Foundation, 1984), 12-38.

[51] Dudley, *Notes on Social Measurement*, xiii.

> role of social upheaval in cracking custom's cake—would seem to be grist for the mill of a sociology of measurement. [...] As for academic sociology, it may be that our sporadic interest in the measurement of time and the temporal framework of social organization will prove to be the entering wedge for a sociological metrology.[52]

Following historian Hunter Dupree, Duncan stressed that metrology is a multidisciplinary inquiry into *measurement understood as a historical social process*, an investigation that ought to see measurement and measurers (those who measure) as part of human culture.[53]

Finally, Duncan defied future scholars to keep expanding the field: "it will require a good many more sociological sophisticated monographic studies before we can expect to see a good comparative treatise on the sociology of measurement"[54]—I would be lying if I said that this challenge did not push me to complete this investigation and answer his call.

Of course, to arrange a sociological enquiry on measurement one should also use help from other disciplines outside of sociology, mostly from what historians call *historical metrology*. Broadly defined, historical metrology is an "auxiliary science of history" dedicated to the study of ancient weights and measures. There have been two

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[52] Dudley, *Notes on Social Measurement*, vii, 26-27.

[53] Dudley, *Notes on Social Measurement*, 13. The works of Hunter Dupree are of great relevance for anyone interested in sociological approach to measurement, see for example: "The Pace of Measurement from Rome to America," *The Smithsonian Journal of History* 3 (1968): 19-40; "Metrication as Cultural Adaptation," *Science* 185 (1874): 208; "John Quincy Adams and the Uniformity of Weights and Measures in the United States," Introduction to *Report of the Secretary of State upon Weights and Measures: Prepared in Obedience to a Resolution of the House of Representatives of the Fourteenth,* by John Quincy Adams (New York: Arno Press, 1980), v-xv.

[54] Dudley, *Notes on Social Measurement*, 12-13.

major areas of emphasis in historical metrology. The first one dedicated to the limited matter of describing what measures were used in the past and finding their equivalencies in relation to modern systems of measurement—e.g. problems like how the Incas measured land during the era of Túpac Amaru or what was the weight of the pound used in colonial Philadelphia for the commerce of corn weigh. Questions of this nature have been crucial for economic historians, historians of science and technology, and archeologists who want to understand the evolution of prices, the construction techniques of ancient civilizations, and so forth.

The other area of analysis in historical metrology can be called "social history of weights and measures." Here the technical details of measuring are not as important, and what matters most is the broader context of social activities and institutions related to weighing and measuring. A definition by Witold Kula—the most influential historian of measures in the twentieth century—can clarify this idea:

> Historical metrology is concerned with past systems of measurement. This definition, in which the emphasis is on the term "system" postulates that in our investigations we take into account all the elements associated with measuring: systems of counting, instruments of counting, methods of using these instruments [...], the different methods of measuring in different social situations, and finally, the entire associated complex of interlinked, varied, and often conflicting social interest. Our definition incorporates also the conviction that all those elements combine into an internally articulated structured whole, and thus into a system. It is the task of science to investigate this system, and to locate it within the social totality that has produced it and within whose framework it functions.[55]

[55] Kula, *Measures and Men*, 94.

Thus, what is important is not only to describe the development of legislation and physical standards of measurement, but to study, for example, "the social significance of earlier practices or the broader agendas of both scientists and politicians that shaped the development of metric units."[56] That is what a "social historical metrology" attempts to do.

The history of the creation of the metric system during the convoluted years of the French revolution, underscoring the heroic journeys of astronomers Jean-Baptiste Delambre and Pierre Mechain, has been a favorite topic for metrological historians, like Antonio E. Ten in the 1990s.[57] More recently Denis Guedj,[58] Charles Coulston Gillispie,[59] and Ken Alder[60] have published new accounts of the invention of the metric system, flashing rich sociological insights that connect the scientific endeavor required to put in place the new measurement system with the larger social context of the revolution.

Social studies of science have been another fertile field for topics related to metrology and standards. A recent example is Linda Derksen's work on measurement in

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[56] Peggy Kidwell, review of *Revolution in Measurement: Western European Weights and Measures since the Age of Science,* by Edward Zupko, *Isis* 83:1 (1992), 111.

[57] Antonio E. Ten, *Medir el metro: La historia de la prolongación del arco de meridiano Dunkerque-Barcelona, base del sistema métrico decimal* (Valencia, Universitat de Valencia, 1996).

[58] Denis Guedj, *Le mètre du monde: Historie politique, scientifique et philosophique de l'invention du système métrique decimal* (Paris: Editions du Seuil, 2000), for this book, which has not been translated into Eglish yet I followed the Spanish version, *El metro del mundo* (Barcelona: Anagrama, 2003). This a different work than Guedj's novel on Delambre and Mechain, *The Measure of the World* (Chicago: University of Chicago Press, 2001).

[59] Charles Coulston Gillispie, *Science and Polity in France: The Revolutionary and Napoleonic Years* (Princeton: Princeton University Press, 2004), 223-285, 458-494.

[60] Alder, *The Measure of all Things.*

DNA profiling, who stresses the idea that "measurement is the outcome of negotiation."[61] Touching partially on that case is the work of Aryn Martin and Michael Lynch on the politics of counting.[62] Signaling how metrological problems can serve to illuminate larger social issues, Bruno Latour provided a vivid image of the intricate relations that involve the functioning of the metric system:

> We can say that the sociology of the social circulates in the same way as physical standards do or, better yet, that social sciences are part of metrology. Before science studies and especially ANT, standardization and metrology were sort of dusty, overlooked, specialized, narrow little fields. This is no wonder since their truly wonderful achievements were cut off by the gap between local and global […]. As soon as local and global disappears, the central importance of standards and the immense advantages we draw from metrology—in the widest acceptance of the term—become obvious. Take, for instance, the case of the platinum kilogram maintained by the International Bureau of Weights and Measures in a deep vault inside the Breteuil Pavillon at the Sevres park outside of Paris. Is it a convention? Yes. Is it a material object? Yes. Is it an international institution? Once more, yes. Does it represent the head of a metrological chain, the ideal model to which all other inferior copies are compared in a solemn ceremony once every two years? Again, yes. There is no doubt that it is a hybrid. And yet it is exactly those confusing entities that allow all the metrological networks of the world to have some sort of 'common weight'. Is a metrological reference like the kilogram local or global? Local, since it always resides somewhere and circulates inside special boxes using specific signals, at certain specified times, following specific protocols. Is it global? Sure, since without standards like the watt, the newton, the ohm, the ampere, that is, without the Systeme International d'Unites, there would be no global of any sort because no locus

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[61] Linda Derksen, "Towards a Sociology of Measurement: The Meaning of Measurement Error in the Case of DNA Profiling," *Social Studies of Science* 30 (2000): 803-845.

[62] Aryn Martin and Michael Lynch, "Counting Things and People: The Practices and Politics of Counting," *Social Problems* 56 (2009): 243-266.

> would have the 'same' time, the 'same' distance, the 'same' weight, the same intensity of electric current, the same chemical 'reagents', the 'same' biological reference materials, etc. There would be no baseline, no benchmark. All sites would be incommensurable for good.[63]

From other fields more or less related to historical metrology, scholars like Alfred Crosby and I. B. Cohen have tried to sketch the crucial role of quantification in Western societies.[64] Wendy Nelson Espeland and Mitchell L. Stevens made interesting inquiries into commensuration as a social process.[65] And historians like Patricia Cline Cohen and Sarah E. Igo, focusing respectively in nineteenth- and twentieth-century America, have studied the reactions of people to the expansion of social measurement (census, surveys, etcetera).[66]

I will not try to exhaust here the literature list pertinent for this dissertation, as I will discuss in different chapters the key works that are pertinent for the analysis of the metric system vis-à-vis state formation, economy, and science.

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NB: unless otherwise indicated, translations into English from primary sources in Spanish throughout the dissertation are mine.

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63 Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network-Theory* (Oxford: Oxford University Press, 2005), 227-229.

64 Alfred W. Crosby. *The Measure of Reality: Quantification and Western Society, 1250-1600* (Cambridge: Cambridge University Press, 1997); I. B. Cohen. *The Triumph of Numbers: How Counting Shaped Modern Life* (New York: Norton, 2005).

65 Wendy Nelson Espeland and Mitchell L. Stevens, "Commensuration as a Social Process," *Annual Review of Sociology* 24 (1998): 313-343.

66 Patricia Cline Cohen, *A Calculating People: The Spread of Numeracy in Early America* (Chicago: University of Chicago Press, 1992); Sarah E. Igo, *The Averaged American: Surveys, Citizens, and the Making of a Mass Public* (Cambridge: Harvard University Press, 2008).

CHAPTER I

Around the World in Eighty Thousand Days:

The Global Diffusion of the Metric System, from France 1795 to Saint Lucia 2000

> Since Russia still operated by the Julian calendar, which was thirteen days behind the Gregorian calendar adopted everywhere else in the Christian of Westernized world, the February revolution actually occurred in March, the October revolution on 7 November. It was the October revolution which reformed the Russian calendar, as it reformed Russian orthography, thus demonstrating the profundity of its impact. For it is well known that such small changes usually require socio-political earthquakes to bring them about. The most lasting and universal consequence of the French revolution is the metric system.[1]
>
> *Eric Hobsbawm*

> The institutionalization of the metric system involved special difficulties because of the aspiration to universalism that helped to give it form. This universalism was consistent with the ideology of the revolution, and more particularly with the ideology of empire.[2]
>
> *Theodore Porter*

> The increasing standardization of measures through time is an excellent indicator the most powerful historic process—the process of waxing unity of mankind.[3]
>
> *Witold Kula*

The efforts to design a rational system of measurement by the French revolutionaries culminated in 1799 with an international meeting of scientists held in Paris—the Congress on Definite Metric Standards—where French savants participated with colleagues from the Batavian Republic, Cisalpine Republic, Denmark, Helvetian

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1 *The Age of Extremes* (London: Abacus, 1995), 57.

2 *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life* (Princeton: Princeton University Press, 1995), 26.

3 *Measures and Men* (Princeton: Princeton University Press, 1986), 101.

Republic, Ligurian Republic, Kigdom of Sardini, Spain, Roman Republic, and Tuscany to finish the calculations and verifications to determine the length of the basic unit of the decimal metric system, the meter. The congress was a solid first step to achieve the internationalization of the system, which was one of the central aims of its creators.

In the original proposal to create the metric system at the beginning of the revolution, it was to be made with the collaboration of British scientists. The growing hostility between France and England sank that part of the plan as the revolution continued. And something similar happened with the United States, with Thomas Jefferson distancing himself from the proposal of the National Assembly, after having shown some initial interest of the idea of an international measurement system. The fact that neither England nor America participated in the 1799 Paris Conference has had lasting consequences for the further development of the metric system in the last 200-plus years.

In 1791, when describing the aspirations behind the creation of a new system of measurement, one made by enlightened men, Condorcet underlined the idea that such a system should embrace all people and all ages. That eventually turned out to be the motto of the metric system, *À tous les temps, à tous les peuples* ("For all time, for all people"). Condorcet's vision—so ambitious, so optimistic—has come very close to reality. The metric system has become the only universal language to express quantities of length, mass, and volume in all realms of human activity. From astrophysics and textile design, to food recipes and gold selling, to school teaching and pharmacy, we use meters, liters, and kilograms as gauging tools. In two centuries the metric system has ousted hundreds of thousands of local, regional, and national units of measurements, some of which had been around for more than a thousand years. How did this happen?

In this chapter I will trace the path of the metric system from the narrow corridors of scientific societies and bureaucratic agencies in Paris at the end of the eighteenth century, to the rest of the countries in the globe at the beginning of the twenty-first century. Today ninety-five percent of the world population lives in countries where the metric system is the only legal system of measurement (or at least it is committed to achieve full metrication); the other five percent lives in the seven countries where the metric system is only optional—i.e. it can be used legally, but its utilization is not mandatory. This makes the metric system the only measurement system with which a commercial or civil contract can have validity in every single nation of the planet.

What we know about global metrication

Surprisingly, there is a considerable lack of thorough research on the international propagation of the metric system. Most accounts pay a great deal of attention to the creation of the system during the French revolution and to its technical novelties. Little is known, however, about the details of how the meter spread throughout the world, and why.

The few scholars who have traced the international diffusion of the metric system have done it based on limited—and sometimes inadequate—information and usually with a strong emphasis on what happened on a few—mostly European— countries. Researchers have done meticulous investigation when focusing on single cases (e.g.

Russia, Spain, Ottoman Empire, etcetera), but they rarely connect those single national cases with the larger global process (or they do it in a rather superficial way).

Since the 1960s almost no academic work has traced the global metric spread, which means that the frantic metrication activity that took place during the last decades of the twentieth century has been completely overlooked. Besides, what has happened outside Europe has been almost completely ignored. The role played by colonialism in spreading the meter throughout the world has been overlooked; the same goes for the crucial role of Latin American countries, during the second half of the nineteenth century, to create the critical mass needed to generate momentum for the metric system outside the old continent.

The International Bureau of Weight and Measures (BIPM), the organization in charge of ensuring world-wide uniformity used to keep track of the pace of international metrication and produced some of the most complete and reliable reports on the matter, but stopped doing so in the early 1970s. Since then the matter of how widespread the metric system is has been a matter of little research and much speculation. How bad has this situation become? An anecdote may serve as illustration. When I reached the BIPM asking for records about the countries that have switched to the metric system, I received a response from the Head of Communication and Information Section saying that such is “no longer the duty of the BIPM” and that I may get “recent information on countries/states which have adopted the International System of Units (SI, current name of the metric system) looking at the Wikipedia website."[4] The BIPM's refusal to keep gathering metrication data has created a big gap in our understanding.

On the whole, the information on international metrication is deficient and dated, and the analytical approaches used so far have neglected crucial phases of this process. It is the aim of this chapter to amend at least some of these deficiencies. (In chapter four I will touch into the crucial—though rarely asked—question of why countries decided, once they resolved to abandon their customary measures, to adopt the metric system and not some other modern measurement system.)

Data and methodology

For my analysis I have assembled what is, to my knowledge, the most complete and accurate dataset on global metrication country by country (even if it still requires considerable improvements). I have cross-compared, corrected, and updated the existing datasets (all of them, even the more comprehensive, are either dated or incomplete)[5] and

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[4] Email communication, Françoise Joly, Head of Communication & Information Section, BIPM, September 30, 2010. I need to say that Wikipedia's article on "Metrication," is actually a gallant effort, but one with all the shortcomings prevailing in the existing literature.

[5] The main bibliographical sources are: Frederick Barnard, *The Metric System of Weights and Measures* (New York: Columbia College, 1872); G. D. Burdun, "Worldwide Dissemination of the Metric System," *Measurement Techniques* (1968): 1147-1151; Aubrey Drury, "The Metric Advance," *Measurement* 1, no. 3 (1926): 6-7; E. Lewis Frasier, "Improving an Imperfect Metric System," *Bulletin of the Atomic Scientists* 30, no. 2 (1974): 9-12; *Letter of the Secretary of the Treasury, in Response to A Resolution of the House of Representatives, Transmitting certain Reports in Reference to the Adoption of the Metric System* (Washington: Government Printing Office, 1878); Ch.-Ed. Guillaume, *Les récents progrès du système métrique* (Paris: Gauthier-Villars, 1913); William Hallock and Herbert Treadwell Wade, *Outlines of the Evolution of Weights and Measures and the Metric System* (New York: Macmillan, 1906); Arthur E. Kennelly, *Vestiges of Pre-Metric Weights and Measures Persisting in Metric-System Europe* (New York: The Macmillan Company, 1928); Bruno Kisch, *Scales and Weights: A Historical Outline* (New Haven: Yale University Press, 1965); Henri Moreau, *Le système métrique* (Paris: Chiron, 1975); Musée National des Techniques, *L' aventure du mètre* (Paris: Le Musée, 1989); National Industrial Conference Board, *The*

complemented the results with my own research (reading official documentation on metric adoption from numerous countries and consulting with national experts, metrological agencies, and diplomatic offices). This research makes possible to pin-point when every independent country existing today adopted the metric system, and to determine accurately which countries have not adopted the metric system—a topic much discussed among pro- and anti-metric groups, but not researched at all.

The result is a dataset that includes 196 countries according to the grid of national states in 2010. The information is divided by:

1) present name of the country;
2) year of the first legislation ordering *compulsory* metrication in that country;
3) when applicable, the year when the use of the metric system became optional—i.e., when it could be used legally, but before it was made compulsory;
4) the years of further legislations regarding metrication in the country;
5) whether the adoption was voluntary (i.e., result of a sovereign decision by an independent country) or non-voluntary (i.e. an imposition by a

Metric versus the English System of Weights and Measures (New York: The Century Co., 1912); Albert Gustave Léon Pérard, *Les récents progrès du système métrique, 1948* (Paris: Gauthier-Villars, 1949); United Nations, *World Weights and Measures: Handbook for Statisticians* (New York: United Nations, 1966); U. S. Metric Association. "Metric usage and Metrication in Other Countries," accessed March 25, 2010, http://lamar.colostate.edu/~hillger/internat.htm; Albino Zertuche, *Estudio sobre pesas y medidas en los países centroamericanos* (United Nations, 1958); Ronald E. Zupko, "Worldwide Dissemination of the Metric System during the 19th and 20th Centuries," *Metric System Guide Bulletin* 2, no. 2 (1974): 14-25; and Ronald E. Zupko, *Revolution in Measurement: Western European Weights and Measures since the Age of Science* (Philadelphia: American Philosophical Society, 1990). *Encyclopedia of the Nations*, 2010, http://www.nationsencyclopedia.com. Particularly useful were Moreau's and Zupko's works, unfortunately the information is now dated. Also helpful, but not always accurate and consistent in its use of data, is the list assembled by the US Metric Association.

foreign colonial power or by a larger political entity from which the present country seceded);

6) when applicable, the political entity from which the present country gained independence (whether that other entity forced the metric system into that territory before independence or not, but it is a relevant piece of information for non-voluntary adoptions);

7) when applicable, the year when independence was gained by the present country;

8) and the number of years before or after one of the country's neighbors adopted the metric system.

Appendixes 1 and 2, and Figures 1 to 4 condense in a table and maps the information of the dataset.

To mark the beginning of metrication in a single country I decided to use the year of the first legislation (and in the few cases in which it was appropriate, the signature of an international agreement) ordering exclusive and compulsory use of the metric system in that state. This excludes as marking criteria those legislations that only made the metric system optional (like the United States in 1866; Chile in 1848, before the definite adoption in 1865; or Russia in 1899, before the definite adoption in 1918).

Contrary to other criteria sometimes used to trace global metrication, I have kept aside the moment when the actual enforcement of the metric legislation started taking place, which sometimes happened several decades after the first legislation was approved (like in Mexico, where the first official provision for compulsory metrication dates from 1857, but actual policing did not take place until 1896). There are two reasons behind this selection criterion. First, I am interested in when countries were first committed to fully switching to the metric system, even if they were not successful in the initial implementation (which it is a much harder, costlier, and slower affair). Second, it is very complicated to track the actual changeover to the metric system due to the messiness of the process, which has many gray areas to determine how thorough the transition has been at any given time. Some have tried, for example, to set some reference points to determine when the metric system has permeated larger sectors of a society, like when street signs or weather reports have gone metric, but these are hardly reliable benchmarks (by going into detail with the cases of Mexico and the United States in the following chapters I will show the untidiness and subtleties of metrication on the ground, but it is impossible to do so in every single case).

There are at least two important limitations when studying the global spread of the metric system in the way I am doing here. First, by using independent countries as the units of observation two crucial elements are missed: a) what happened *within* every country, once the adoption was made, to convince or force their respective populations to use the metric units; b) how individuals, associations, and organizations appropriated the metric system even if they were not required to do so by law. In the dissemination of the metric system, the adoption by a nation state tells just half of the story, as the official adoption does not mean that the population actually will use it. The second half of the story is what happens within those countries—which in some ways is the real story (as I will show in detail while looking at the case of Mexico in the following chapters). This is critical to understanding why many countries are still trying to introduce the metric system, even decades after the official adoption was registered (like, to mention just one example, South Korea, which officially became metric in 1949, but as late as 2008 was still launching campaigns to make the reform tangible).[6]

While analyzing the process of metric diffusion I distinguish between *voluntary adoptions* (made by independent, sovereign countries) and *non-voluntary* or *coerced adoptions* (when a foreign power imposed the metric system on a given population under their jurisdiction). Also, I do not include among the voluntary adoptions those nations that seceded from a metric country and retained the same system of weights and measures—a typical example of this are the former Soviet republics that gained its independence seventy years after the metric system was introduced by the USSR and decided to stick with the meter as their official standard.

This dataset opens the possibility of analyzing on a global scale the patterns of diffusion of the metric system—at least in the crucial aspect of national adoptions. It also gives us the opportunity to explore some hypotheses about geographical and historical factors that shaped the specific direction of this development.

By making an analysis that covers all national cases in the diffusion process it will be easier to detect the commonalities and particularities of the American and Mexican cases that will be the focus of the following chapters.

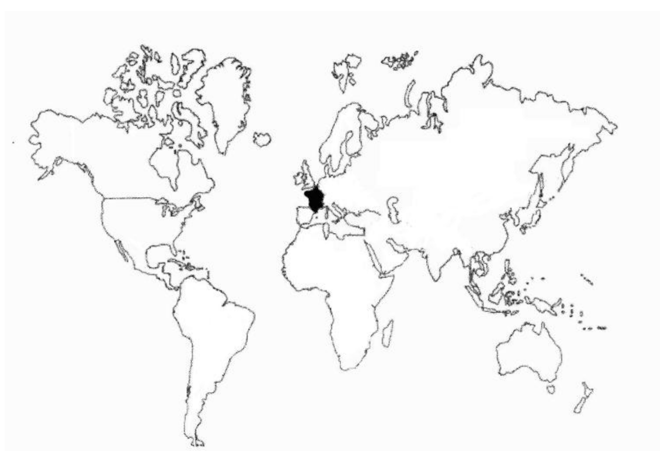
[6] Lee Joon-Seung, "South Korea Determined to Introduce Metric System," *Yonhap News Agency,* July 22, 2007, acceded May 11, 2008, http://english.yonhapnews.co.kr/business/2007/07/22/86/-0502000000aen20070721002200320f.html.

How Did Global Metrication Happen? The Big Picture

Let's start with a brief panoramic view of how the metric system spread throughout the planet. Figures 1 to 5 show five stages of the global pace of metrication from 1800 to 2000, over 50-year spans, presenting the geographical spread of the system highlighting the countries and colonies where it was officially adopted.

Territories in black denote the countries and colonies that switched to the metric system. Underneath the maps are listed the countries that adopted the metric system in that period and the number of voluntary and coerced adoptions. Underlined names in the lists indicate countries where the metric system was implanted when they were under the control of a colonial power, and names in brackets **[ ]** are countries that eventually seceded from larger metric nations.

Figure 1. Metric System in the World, 1800: Revolutionary Genesis



Adopter: France.

Figure 2. Metric system in the world, 1801-1850: Napoleonic Expansion

New adopters: United Kingdom of the Netherlands [today Belgium and Netherlands], Luxembourg, Algeria, Senegal, Spain.
New voluntary adoptions in this period: 3.
New coerced adoptions in this period: 2.

Figure 3. Metric system in the world, 1851-1900:

Latin American, Western Europe, and Colonial Western Africa Expansions

New adopters: Portugal, Colombia, Monaco, Mexico, Venezuela, Cuba, Italy, Brazil, Peru, Uruguay, Romania, Chile, Ecuador, Dominican Republic, Bolivia, Germany, Turkey, Suriname, Austria [and today Croatia, Czech Republic, Liechtenstein, Montenegro, Slovenia, Slovakia], Serbia, Hungary, Sweden, Switzerland, Mauritius, Argentina, Seychelles, Bosnia and Herzegovina, Costa Rica, Norway, French West Africa [today Benin, Chad, Côte d'Ivoire, Mauritania], Niger, Congo [today Republic of the Congo], El Salvador, Finland, Bulgaria [including today Macedonia], Sao Tome and Principe, Tunisia, Nicaragua, Honduras, Djibouti, Paraguay, Puerto Rico, Iceland, Equatorial Guinea.
New voluntary adoptions in this period: 31.
New coerced adoptions in this period: 13.

Figure 4. Metric system in the world, 1901-1950:

Soviet, Asian, and Colonial Central Africa Expansions

New adopters: <u>Guinea</u>, <u>Angola</u>, <u>Cape Verde</u>, <u>Guinea-Bissau</u>, <u>Mozambique</u>, <u>Philippines</u>, Denmark, San Marino, <u>Burundi</u>, <u>Congo</u> [today Democratic Republic of Congo], <u>Rwanda</u>, Guatemala [including today Belize], <u>Malta</u>, <u>Vietnam</u>, Thailand, China, <u>Comoros</u>, Panama, Mongolia, Russia/USSR [today Armenia, Azerbaijan, Belarus, Estonia, Georgia, Latvia, Lithuania, Moldova, Ukraine, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan], Poland, Haiti, <u>Morocco</u>, <u>Western Sahara</u>, <u>Cambodia</u>, <u>Libya</u>, <u>Indonesia</u>, Afghanistan, <u>Togo</u>, Iran, Iraq, Lebanon, <u>Syria</u>, Andorra, North Korea, South Korea, Israel, Albania.
New voluntary adoptions in this period: 19.

New coerced adoptions in this period: 19.

Figure 5. Metric system in the world, 1951-2000: Commonwealth Expansion

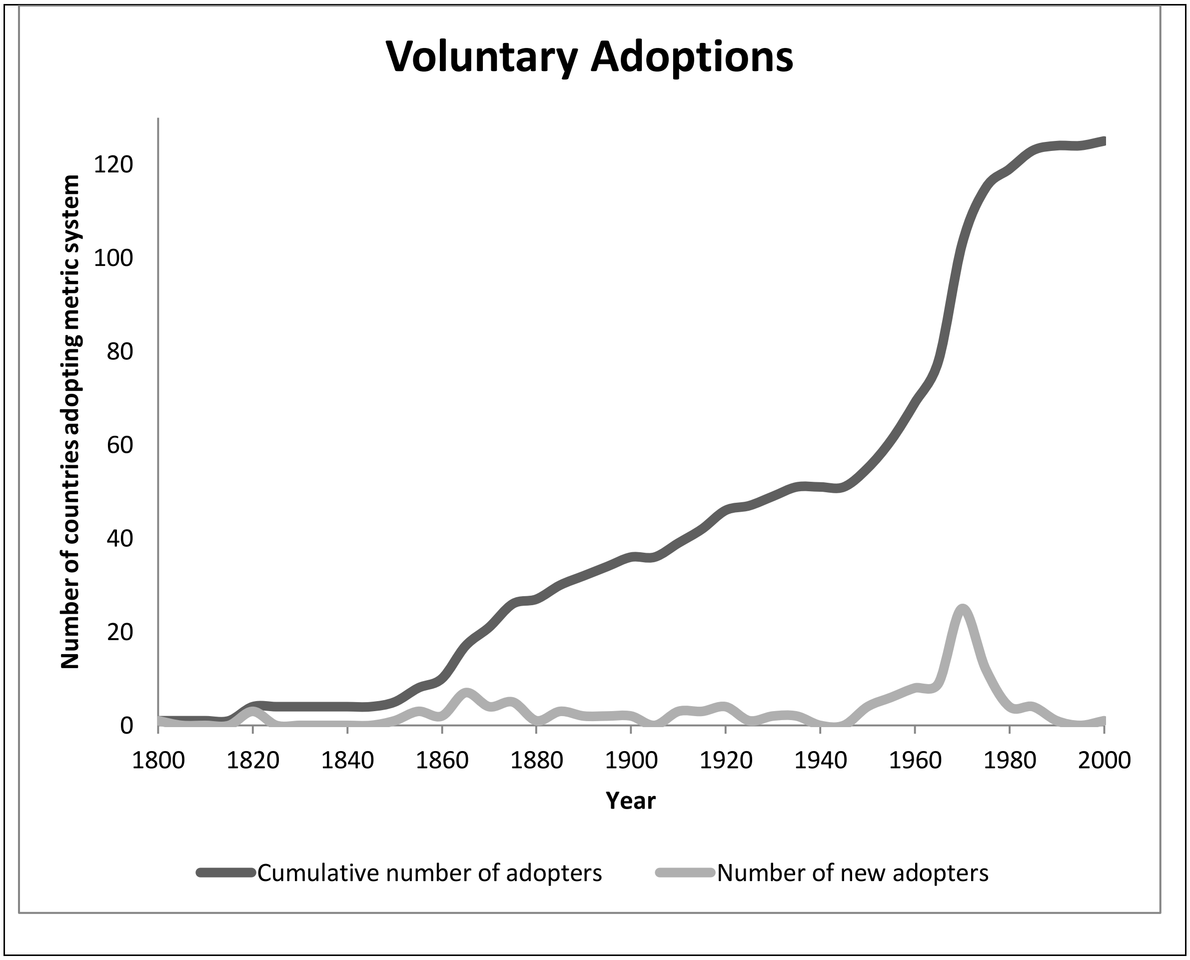
New adopters: Japan, Egypt, Bhutan, Taiwan, Jordan, Sudan, India, Madagascar, Macau, Timor-Leste, Greece, Maldives, Burkina Faso, Central African Republic, Gabon, Mali, Somalia, Cameroon, Kuwait, United Arab Emirates, Nigeria, Ethiopia (and today Eritrea), Laos, Nepal, Saudi Arabia, United Kingdom, Kenya, Tanzania, Uganda, South Africa (and today Namibia), Pakistan, Ireland, Singapore, Botswana, Swaziland, Zimbabwe, The Bahamas, Dominica, Grenada, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Bahrain, Australia, New Zealand, Lesotho, Zambia, Canada, Trinidad and Tobago, Sri Lanka, Papua New Guinea, Solomon Islands, Guyana, Malaysia, Ghana, Cyprus, Qatar, Fiji, Barbados, Jamaica, Nauru, Antigua and Barbuda, Oman, Tonga, The Gambia, Malawi, Sierra Leone, Tuvalu, Yemen, Bangladesh, Kiribati, Brunei, Vanuatu, Saint Lucia.

New voluntary adoptions in this period: 70.

New coerced adoptions in this period: 3.

Figure 6 condenses the information about the voluntary adoptions in this 200-year span and shows how the rate of new adoptions from 1800 to 1850 remained relatively stable, with only a small climb shortly after the 1850s (mainly due to the adoptions in Latin America). It is in the 1960s and 70s when we see a sharp increase (as a result of the adoptions made by the newly independent countries formerly part of the British Empire) and drops quickly in the 1980s. The twenty-first century has not registered any adoption (voluntary or not).

Figure 6. Voluntary Adoptions of the Metric System by Country, 1800-200



As of today there are seven *non-metric countries* in the world: Liberia, Myanmar, United States, Independent State of Samoa, Federated States of Micronesia, Palau, and Marshall Islands. In the discussions about metrication it is widely assumed that there are only three non-metric countries (Liberia, Myanmar, and the United States), an unfounded assertion that has taken a life of its own and has been repeated thousands of times for more than a decade by academics and persons interested in the history of the metric system (me included). I did not consider the causes that have prompted people to withdraw the four Oceanian nations out of the non-metric category, but they certainly have not adopted the metric system.

Summing up this information, among the present 196 independent countries 125 countries (sixty-four percent of the total) have adopted the metric system voluntarily; in 38 countries (nineteen percent) the system was introduced when they were colonized territories; another 26 countries (thirteen percent) seceded from countries that were already metric; and 7 countries (four percent) have not adopted the metric system.

These charts and numbers give a broad idea of how and when the metric system extended around the world, and some general tendencies of diffusion are also visible from this bird's eye perspective. But we need much more study and contextualization to figure out why and when some countries, and not others, went metric. In what follows I will undertake two different forms of analysis of this process. First, I will tackle the figures from the dataset trying to find geographical patterns by looking at countries as nodes in a diffusion network. Secondly, I will look the historical conditions that fashioned the dissemination of the metric system.

1. VICINITY AND DIFFUSION NETWORKS

A corpus of literature that may bring some insights to analyze the global spread of the metric system is *diffusion research,*[7] and more specifically the idea of "diffusion in networks" which is centered on "how behaviors, practices, opinions, conventions, and

[7] This theory was condensed in the famous work by Everett Rogers, *Diffusion of Innovations* (New York: The Free Press, 1995).

technologies spread […] through a social network" as the members of that network influence other members to which they are tied.[8]

The central thesis of this theory is that the choices made by individuals depend on what other people do; individuals (or social groups, organizations, states, etc.) are influenced by their particular *network neighbors*. People often do not care as much about the full population's decisions as about the decisions made by friends and colleagues. For instance in a professional environment people may choose technology to be compatible with the people they directly collaborate with, rather than the universally most popular technology. Among the benefits of imitating others' behavior is that people have incentives to adopt an innovation when they have to communicate with associates who have already adopted a technology (e.g. fax, email). The benefits of adopting a new convention or idea increase as more and more neighbors do the same.[9]

It is possible to use the idiom of this theory in our analysis of metric diffusion. The unit of analysis would be the global network of countries, analyzed in the two-hundred-years span between the end of the metric conference of 1799 in Paris and the year 2000, when the latest metric adoption was registered. This network is contained in a closed space—planet Earth—but is very dynamic. The number of its units and clusters has expanded and contracted continuously, and it has experienced numerous changes in its configuration through the decades. Empires have dissolved into dozens of independent

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[8] David Easley and Jon Kleinberg, *Networks, Crowds, and Markets* (New York: Cambridge University Press, 2010), 498.

[9] Easley and Kleinberg, *Networks, Crowds, and Markets,* 497-536.

countries; small countries have merged to form middle size nations, just to dismember again years later.

With the principles of network diffusion in mind, it is plausible to assume that as more countries adopted the metric system it was less risky, more beneficial, and then more probable for other countries to also adopt it. More specifically, the chances that a country would switch to metric would grow significantly if its close associates had made the change. Then we can advance the hypothesis that geographical vicinity played a significant role in shaping patterns of diffusion of the metric system. If one of the main purposes of switching to the metric system was to facilitate international coordination, it seems plausible that nation-states wanted to be on the same page as their neighbors regarding metrological standards. If this is the case indeed, we should see that if one of your neighbor countries adopted the system the chances of you adopting it as well should increase significantly.

A way to test this assumption is to see what kind of role geographical vicinity has played in the diffusion of the metric system. To this aim I determined how many years passed for every country to embrace the metric system after one of its neighbors had done. Since this conjecture supposes that the spread of the innovation is the product of a conscious decision I have to limit the analysis to cases of *voluntary adoption* (this of course leaves out many countries whose processes of metrication fell in the category of coerced adoption, but I will be back with those cases later on).

As I said earlier, among the present 196 independent countries in the world, 125 adopted the metric system voluntarily; eleven of them switched to metric system without having a metric neighbor. These *isolated voluntary adopters* are France (which for the obvious reason that invented the system did not have metric neighbors in 1795), Colombia, Mexico, Romania, Costa Rica, El Salvador, China, Bhutan, Saint Kitts and Nevis, Nauru, and Canada.

This leaves us with 114 countries that adopted the metric system voluntarily and had at least one metric neighbor when they made the switch. On average these nations adopted the metric system sixteen years after at least one of their neighbors went metric. This number may look too high to show any relevant connection between metric acceptance and geographical vicinity. However, things may look somewhat different if we consider that the median number of years is four, and that the value that occurs most frequently (mode) is zero years.

Indeed, nineteen countries (seventeen percent of the 114 non-isolated voluntary adopters) went metric exactly the same year as some of their neighbors. These simultaneous adoptions happened at different points in history and in diverse geographical contexts, from Brazil and Peru in 1862, to Burkina Faso and Mali in 1960, to Australia and New Zealand in 1969.

In addition, sixty-two countries (a bit more than half of the cases in this category of non-isolated voluntary adopters) adopted the metric system within five years after one of their neighbors did. To mention some examples, Afganistan (1923) went metric one year after the Soviet regime metrified Afghan neighbors Uzbekistan and Turkmenistan in 1922; Somalia (1960) and Ethiopia (1962) made the transition within two years distance; Buthan (1951) and India (1954) within three years; Norway (1882) and Finland (1886) within four years; Saint Kitts and Nevis (1969) and Antigua and Barbuda (1974) within five years.

Finally, two thirds of the total—seventy-five countries—made their transition to metric within 10 years after one of their neighbors. Such was the case, for example, with Albania (1948) and Greece (1957), or with Fiji (1972) and Tuvalu (1978).

These global patterns are relatively constant from region to region[10] and strongly suggest the idea that vicinity was an influential factor in international metric diffusion.

What still remains difficult to understand, from this viewpoint, are the outliers. Why did Mexico (1857) have to wait fifty-three years before one of its neighbors (Guatemala in this case) followed suit? Why did Guinea (1901) have to wait seventy-five years before Sierra Leone went metric also? Why did Andorra remain non-metric for eighty-five years after both of its neighbors (France and Spain) made the transition? Why did Guyana (1971) accept the meter one hundred years after the last of its neighbors (Suriname, 1871) did so? Questions of this kind require another class of explanation, as I will try to show in the next section.

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[10] In the Americas 14 out of 25 countries that adopted the metric system voluntarily (excluding 6 isolated voluntary adopters) had a neighbor that adopted the system within the previous five years (i.e. 56 percent of the cases); the total average in the continent is 19 years. In Africa: 15 out of 24 countries that adopted the metric system voluntarily had a neighbor that adopted the system within the previous five years (i.e. 62 percent of the cases); the total average is 16 years. In Asia: 16 out of 30 countries that adopted the metric system voluntarily (excluding the 2 isolated voluntary adopters) had a neighbor that adopted the system within the previous five years (i.e. 53 percent of the cases); the total average is 11 years. In Europe: 12 out of 26 countries that adopted the metric system voluntarily (excluding the 2 isolated voluntary adopters) had a neighbor that adopted the system within the previous five years (i.e. 46 percent of the cases); the total average is 22 years. Finally, in Oceania: 6 out of 9 countries that adopted the metric system voluntarily (excluding the one isolated voluntary adopter) had a neighbor that adopted the system within the previous five years (i.e. 67 percent of the cases); the total average is 4 years.

But before that, there is another idea in network diffusion theory that is worth exploring here. According to Easley and Kleinberg, since nodes in a network make choices based on the choices of their neighbors, when diffusion starts a particular pattern of behavior begins to spread across the links of the networks, like *cascades*. There are two types of cascades of adoptions, one in which the cascade runs for a while but stops, the other in which every node in the network switches (a complete cascade). In a network where nodes care about what their immediate neighbors are doing, it is possible for a small set of initial adopters to a domino effect that may spread the innovation through the whole network. However, tightly-knit communities in a network can hinder the spread of an innovation. In this regard, *homophily* can serve as a barrier to diffusion by making it hard for innovations to arrive from outside densely connected communities. Cascades come to stop when they run into dense *clusters*—clusters are considered then the natural obstacles to cascades.[11]

This contraposition between cascades and clusters may shed some light, for instance, on the state of global metrication by 1950 (figure 4), when the large majority of the nations outside the metric sphere were members of the Commonwealth of Nations that gravitated around the United Kingdom. It can also be useful to understand the present state of affairs (figure 5) where, besides the United States, four of the other six non-metric countries of the world have been at some point in their history under

[11] Easley and Kleinberg, *Networks, Crowds, and Markets,* 505, 509.

American administrative control (as I will detail later). The British and American clusters have halted the metric global cascade.

The concept of clusters can be useful as well in explaining why the metric system spread now and then through small groups of nations. Even if the processes of state and nation formation were some of the keys to understanding the success of the metric system in becoming the world's dominant metrological language (as I will argue in the next chapter), international agreements (sometimes among neighboring countries, sometimes not) should be considered another important element to explain it. Evidence of this is the number of cases in which countries decided to switch to the metric system by signing international treaties. There have been at least three of these cases.

- In 1910 Guatemala, El Salvador, Nicaragua, Honduras, and Costa Rica signed a Central American convention relative the regional unification of weights and measures in whole region and chose the metric system to be their common standard.[12] This convention served two purposes, it pushed Guatemala to pass its first metric law, and hard-pressed the other Central American nations to start the actual implementation of their legislations that they had approved in the 1880s and 1890s.
- In 1967 Kenya, Uganda, Tanzania—three nations sharing borders—decided by a joint government declaration to adopt the metric system in place of the Imperial British system.[13] This declaration has been, to my knowledge, the only case in which a treaty with the exclusive purpose of implementing a simultaneous transition to metric is signed by multiple countries.

[12] See Zertuche, *Estudio sobre pesas y medidas en los países centroamericanos*.

[13] Burdun, "Worldwide Disseminatin…," 1151.

- In 1969 the Caribbean Community (CARICOM, whose members are Antigua and Barbuda, Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St. Kitts and Nevis, Saint Lucia, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago) took the decision to move as a group to the metric system. A year later it was agreed by the Heads of Government Conference of the Caribbean Free Trade Association that all member countries will go metric.[14]

Other international institutions designed to facilitate economic integration have helped the advancement of the metric system. The First International Conference of American States (held in Washington DC in 1889) and the subsequent Pan-American Conferences in the nineteenth century drove several Latin American countries to revive and enforce their dormant metric legislation and put pressure on the United States to harmonize its weights and measures with the rest of the continent (as I will discuss in chapter three).

British metrication in the 1960s came about in the midst of the United Kingdom's desire to have a more fluid participation in the European Common Market. Later on the regulations by the European Union forced England and Ireland to go further with their metric transition policies (as happened in Ireland in 2005, when road sign stopped showing miles in favor of kilometers and all new cars had speedometers that displayed only kilometers per hour).

Of course not all international agreements looking for economic integration of a given region have been effective in advancing the metric cause. The signing of the 1994

[14] See Antigua and Barbuda Bureau of Standards, "About the Metrication Process," accessed August 24, 2010, http://www.ab.gov.ag/gov_v2/government/bureau_of_standards/standards_info/metrication.htm.

North American Free Trade Agreement (NAFTA) between two metric countries Canada and Mexico and one non-metric nation (the United States) did not translate into America adopting the meter as its exclusive standard of measurement. The futility of NAFTA regarding metrication shows the limitations of any theory that may try to explain global dissemination of the metric system exclusively on the basis of geographical vicinity or international coordination. In fact NAFTA presents several oddities that the principles of network diffusion aforementioned cannot explain. Mexico was the country that needed to wait the largest for one of its neighbors to go metric after it adopted the system. Fifty-three years elapsed between Mexico's first compulsory metric law and the beginning of metrication of Guatemala in 1910[15]—Canada has the peculiarity of being the only country in the world today that does not share borders with a metric country. North America has to be considered the most anomalous region regarding international standardization of weights and measures (it has to be said, though, that after Mexico made metric compulsory in 1857, the United States accepted the metric as a legal, optional system in 1866, and Canada did the same in 1871, which means the region got fully integrated as a "soft metric" zone in less than fifteen years).

Thus, besides its valuable insights, network theory leaves many loose ends for our analysis. For one thing, all coerced adoptions are kept out of the picture. By looking at nation-states just as nodes in a network we learn very little about domination and conquest (important issues in the spread of the metric system). Network theory is very

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[15] Actually, Mexico is by far the country that had had to wait the most to have a metric neighbor. France, the creator of the system, waited 21 years; Costa Rica had to wait 12 years; the other *isolated voluntary adopters* waited for 10 years or less.

useful for recognizing the value of interconnectivity, but not so much for understanding power; it is easy to assume that all participants in an abstract social network are equal in their resources and influence, and that their singularities come just from their position within a network. But as I will discuss, some countries have had the ability to force others to adopt the metric system; on the other hand, what happens inside every country is frequently more important than what happens outside. This became crucial in explaining, for example, why countries with no metric neighbors, especially those in the nineteenth century, decided to take the risk of making a costly metrological reform in favor of the metric system (Mexico is one of those cases). Finally, network theory does not offer much help either to elucidate why are there still countries that have refused to commit to the metric system (like the United States).

I will explore now some historical factors to clarify how the metric expansion occurred the way it did.

2. WHEN HAVE COUNTRIES ADOPTED THE METRIC SYSTEM? GENERAL TENDENCIES

As suggested in the epigraph by Eric Hobsbawm at the beginning of this chapter, the metric system has been adopted in many countries after they suffered socio-political earthquakes. Depending on the case, these large scale social changes have been:

- revolutions,
- national unifications,
- massive socio-political change,
- colonization and imposition by a foreign power,

- independence from colonial rule.[16]

I would like to say something about these different social processes. However, since some have received considerable attention by scholars I will spent more time on those aspects that have been largely overlooked.

Revolutions

Since the metric system was created during a social revolution, researchers have paid considerable (though not systematic) attention to the links between revolution and measurement. Not surprisingly a great deal has been written about the French revolution and why the metric system was created and implemented exactly in such a mutinous context.[17]

Observers have also been attentive to the fact that China adopted the metric system in 1912 (the very same year that the Qing Dynasty was abolished and the Republic of China established) and in Russia in 1918 (a year after the October Revolution

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[16] What it is true in all these cases is that the adoption of the metric system was an imposition from the top—in different degrees, but always from the top. Sometimes professional groups have adopted the metric system voluntarily, but no large segment of a general population has voluntary abandoned its customary measures and adopted the metric ones before their government decided to make the meter, the liter and the kilogram the only legal units. Metrication "from below" has been rather anemic and it can only be found in certain occupational groups (more specifically in scientific and technological areas), and that is one of the main reasons why non-mandatory adoptions of the metric system, within countries, have never achieved much.

[17] See for example Bronislaw Baczko, "Rationaliser revolutionnairement," in *Les mesures et l'histoire,* ed. Institut D'Histoire Moderne et Contemporaine Centre National de la Recherche Scientifique (Paris: Éditions du Centre National de la Recherche Scientifique, 1984); Ken Alder, "A Revolution to Measure: The Political Economy of the Metric System in France," in *The Values of Precision,* ed. Norton Wise (Princeton: Princeton University Press, 1994); Kula, *Measures and Men,* 228-264; Yannick Marec, "L'ambition revolutionnaire: Mesurer toutes choses rationalment," in *La révolution Française et les processus de socialisation de l`homme moderne* (Paris: Éditions Messidor, 1989), 691-700.

ended tsarism). But, to my knowledge, only a few articles have been published in the Russian case[18] and almost nothing about the Chinese revolution and metrication.[19]

In general, as revolutions tend to alter numerous social and political institutions the metric system becomes part of the efforts to reconfigure society at large.

National Unifications

In some cases, the metric system has aided the goal of national unification. With the purpose of linking together (and subduing) previously autonomous cities, regions, and states with different administrative structures and diverse metrological arrangements, the introduction of the metric system as a shared (i.e. national) system of measurement was seen as an effective solution. (In the next chapter I will go into detail about the connections between metrication and state and nation building.)

This was the case in Germany, where the adoption of the metric system was parallel to the political and administrative reforms that culminated in the 1871 unification under Bismarck. In Italy, similarly, the metric system was established as the standard for the whole peninsula in 1861, the very same year when Rome was proclaimed the capital of Italy and Victor Emmanuel II was declared the first King of united Italy by the

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[18] For example Michael D. Gordin, "Measure of All the Russias: Metrology and Governance in the Russian Empire," in *Kritika* 4 (2003): 783-815; N. A. Shost'in, "History of Russian Metrology: D. I. Mendeleev and the Metric System of Measures," in *Measurement Techniques* 4 (1968): 429-431; K. P. Shirokov, "Fifty Years of the Metric System in the USSR," in *Measurement Techniques* 9 (1968): 1141-1146.

[19] A few comments on the Chinese case can be seen in Endymion Wilkinson, *Chinese History: A Manual* (Cambridge: Harvard University Asia Center, 2000), 239-240.

in Kula, *Measurement and Men,* 284-286.

Parliament. Another instance of metrication as a means to stimulate national unification was Bulgaria, where the metric system became the official standard of measurement in 1888, just three years after the Principality of Bulgaria and the province of Eastern Rumelia were united.

Massive Socio-Political Change

In many cases the metric system was adopted after some form of drastic change in the political regime (like civil war or the adoption of a new constitution).

In Colombia and Mexico, for example, the adoption of the metric system came about the same year as the promulgation of a new liberal Constitution (1853 and 1857, respectively) reforms in both cases that were concomitant with the separation of the church and state, reaffirmation of the abolition of slavery, and like reforms.

What can be called, for lack of a better word, "modernizing" policies have also been an engine of metrication. It is not rare for governments to adopt or implement the metric system at the same time as other wide-ranging reforms are also put into operation: tax and customs reforms, geographical-administrative rearrangements, modifications in land-tenure legislation, large standardization policies, and so on. It is not surprising then that Russia changed to the metric system at the same time as it abandoned the Julian calendar and followed the rest of Europe with the Gregorian calendar. Turkey decided to make effective its 1869 metric legislation as part of Mustafa Kemal's efforts to found a secular republic in the 1920s, which included, besides metrication, the employment of

Latin characters and Arabic numerals, the introduction of surnames following the European style, standardization of the size and color of the flag, and so forth.[20]

By and large the metric system never comes into a country as a discrete, isolated reform; it is always part of a more or less interrelated series of large social and political transformations.

Military Imposition

Writing against Napoleon in his 1814 pamphlet *The Spirit of Conquest and Usurpation*, Benjamin Constant lamented:

> The same code of law, the same measures, the same regulations, and if they could contrive it gradually, the same language, this is what is proclaimed to be the perfect form of social organization. […] The key world of today is uniformity. It is a pity that one cannot destroy all the towns to rebuild them according to the same plan, and level all the mountains to make the ground even everywhere. I am surprise that all the inhabitants have not been ordered to wear the same costume, so that the master may no longer encounter irregular colors and shocking variety.[21]

Constant's words were very appropriate in the context of post-revolutionary France and its methods of exporting metrication. Even before the meter's final magnitude was determined in the 1799 Paris conference, France had been already active in the business of implanting it in other European territories. While spreading the revolution through the invasion of neighboring territories, French authorities promoted the creation

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[20] W. G. Tinckom-Fernandez, "Turks Are Getting Many New Habits," *New York Times*, March 11, 1928; and "Angora Bewilders By Swift Reforms," *New York Times*, June 3, 1928.

[21] Benjamin Constant, *Political Writings* (New York: Cambridge University Press, 1988), 73.

of new republics where the metric system was established as the official system of measurement—freedom, in this new social order, was to be measured in meters.

Starting in 1798, under pressure by the French ambassador in Turin, Piedmont began the introduction of the metric measures, with scientists and public administrators leading the march. In the Cisalpine Republic (Lombardy) it was determined in 1798 that the future measures and currency would be arranged in a decimal scale, and in 1801 the metric system was officially introduced. These two experiments served as the basis for the metrological unification of what would be Italy some decades later—a process that, like the whole unification of the country, was directed from the northern territories.[22]

In Geneva, following instructions from France, the compulsory utilization of the metric system began in 1901. In the departments located in what is today Belgium, administrative centralization came hand in hand with the meter and the kilogram, commencing in Brussels in 1799.[23] This endeavor served as the foundation for the future metrication of the United Kingdom of the Netherlands (later Belgium and Netherlands) in 1816.

The introduction of metric units in these places was longwinded and thorny. Some progress was achieved in major cities, but very little elsewhere, and when the French armies retuned home in defeat the new authorities abolished the metric system and returned to the old measures (at least for a few years). This rejection of the metric system was pretty unusual, in the sense that since then metrication has been a one-way street,

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[22] Kula, *Measurement and Men,* 268-269.

[23] Kula, *Measurement and Men,* 275-277.

once you enter it you cannot go back—the metric system is difficult to adopt and even more difficult to implement, but it looks almost impossible to abandon.[24]

Colonialism

In 1927 Arthur Kennelly, an enthusiastic pro-metric engineer from Harvard University, noted that "since the year 1800, a wonderful sociological phenomenon has presented itself in Continental Europe. […] A group of more than thirty countries […] have, one after another, officially adopted the metric system to the abolition of their respective national systems. The change has been voluntary. In no case […] did the change from national to metric measures come about in any one country, at the dictation of any other country."[25] In his keen evaluation on the metric dissemination Kennelly failed to remember the role of Napoleon's army in the first attempt of metric implementation in Belgium, Switzerland, and Italy; but more importantly, he carefully overlooked what happened outside Europe, where the change to the metric system in many places did come about at the dictation of other countries (European nations in particular).

Even though the voluntary adoption of the metric system by sovereign states is indeed one of the most appealing themes in the global metrication process, it is

[24] The French exportation of the metric measures through military power—within Europe—halted when Napoleon's soldiers marched through Prussia, Austria and Poland, places where Paris did not try to implant the revolutionary system.

[25] Arthur Kennelly, *Vestiges of Pre-Metric Weights and Measures Persisting in Metric-System Europe, 1926-1927* (New York: Macmillan, 1928), viii.

astonishing that colonialism has not been a relevant topic in the historiography of the metric system. Colonialism was a significant element in the globalization of the meter. It would be a big stretch to say that it was the most crucial aspect, but its importance cannot be underestimated. French colonialism in particular had a vital role in advancing the use of the metric system outside Europe, predominantly in Africa.

Metrication by colonization was a process that lasted for more than a century and helped to increase the number of metric territories all over the world, from Algeria and Senegal in 1840 to Macau and Timor-Leste in 1957. Overall, there are 38 current countries (19 percent of the total) where the metric system was introduced when they were colonies or administered territories of overseas powers.[26] And if we focus our attention outside Europe we will find that *one out of every four currently existing countries outside Europe received the metric system as a colonial imposition*.[27]

Breaking down these numbers by regions we can see great variations in this colonial expansion. Africa was the main recipient of the metric blessings brought by European armies, with half of the current African countries (27 out of 54) getting the meter in that way. This is by far the highest proportion of cases of colonial metrication in any continent. In Asia this percentage only got to fifteen percent (7 in 46 cases), and in the Americas it was just eight percent (3 in 36). Oceania's case is the most peculiar; in

[26] These 38 countries are Algeria, Angola, Benin, Burundi, Cambodia, Cape Verde, Chad, Comoros, Côte d'Ivoire, Cuba, Democratic Republic of Congo, Djibouti, Equatorial Guinea, Guinea, Guinea-Bissau, Indonesia, Libya, Macau, Malta, Mauritania, Mauritius, Morocco, Mozambique, Niger, Philippines, Puerto Rico, Republic of the Congo, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Suriname, Syria, Timor-Leste, Togo, Tunisia, Vietnam, and Western Sahara.

[27] This is 37 out of 150 countries.

that continent all ten metric adoptions have been voluntary and the remaining four countries are non-metric.

Among the colonial powers that participated in the military exportation of the metric system France played the leading role. Eighteen of the thirty-eight current countries were the metric system was introduced when they were colonies formerly ruled by France. Other important contributors were Portugal with seven, Spain four, Belgium three, and the Netherlands with two.

We are still waiting for detailed studies that can give us a better understanding of the nitty-gritty of the introduction of the meter in these colonies,[28] but it is not difficult to imagine some of the main instruments of this process. Based on other experiences, it looks reasonable to assume that rights for the possession of land and cadastral records were crucial for the introduction of the new measures of area, and that the payment of taxes in kind was the battering ram in the imposition of grain measures.

The ideological justification for the imposition of the metric system on other populations sometimes took the form of a charitable donation to less advanced people. As an illustration of this we can mention the address by the French Minister of Agriculture at the final ceremony of the Exposition of the Second Republic, in 1849, where he declared that the products exhibited by Algeria in the conference though modest show promise for future development, and in return for their raw products and native handiwork, France had aided Algeria to build wells, irrigation systems, and dams to increased agricultural

[28] Not about the metric system, but illustrative of the problems to standardize measurement units in a colony is Debdas Banerjee, *Colonialism in Action* (New Delhi: Orient Longman Limited, 1999), 49-52.

production; and stressing his idea about reciprocity, the minister claimed that "the Arabs of the Middle Ages gave us their simple system of numbering and their admirable decimal system. We return the gift, so productive for the common good, by giving them our decimal metric system."[29]

Of course, the French did not resign themselves to giving their decimal system only to the Algerians; they shipped it to the rest of their colonies in Africa and their overseas territories in all corners of the world: the Caribbean (in Guadeloupe and Martinique), South America (Guyana), North America (Saint Pierre and Miquelon), the Indian Ocean (Réunion), the southwest Pacific (New Caledonia and Polynesia), Southeastern Asia (Vietnam and Cambodia), and Western Asia (Syria). Apparently they did not have time to introduce the metric measures in Louisiana before it was sold to the United States in 1803—and that prevented what would have been a very interest episode, with America adding a metrified territory to its lot. Neither were they able to give the meter to the rebellious Haitians (who ended up adopting the metric system voluntarily in 1920). But this did not prevent France from giving the Americas a taste of metrication, which was implanted in the island of Saint Pierre and Miquelon in 1824, and in Guyana in 1840.[30]

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[29] *Rapport du jury centrale sur les produits de l'agriculture et de l'industrie exposés en 1849,* vol. I (Paris: Imprimerie Nationale, 1850), lxiv, quoted by Arthur Chandler, "Exposition of the Second Republic: Paris 1849," accessed September 26, 2009, http://charon.sfsu.edu/publications/ParisExpositions/SecondRepublicExpo.html. For a sense of the context in which the metric system was introduced in the French colonies see Tom M. Hill, "Imperial Nomads: Settling Paupers, Proletariats, and Pastoralists in Colonial France and Algeria, 1830-1863" (PhD diss., University of Chicago, 2006): esp. 222.

[30] These are the year of the introduction of the metric system in other French territories and departments: Guadeloupe, 1844; Martinique, 1844; Réunion, 1839; New Caledonia, 1862; Polynesia, 1847. Moreau, *Le système métrique,* 107.

Finally, it is important to notice a peculiar but significant fact. As of today, *no former colony has rejected the metric system after their independence*. This is a phenomenon that we may call *voluntary retention* of the metric system. This is especially surprising considering that many independence movements have been notoriously nationalistic and a return to the "original" or "national" pre-metric measures looked like a good fit to their ideological outlooks. Newly independent countries have made conscious efforts to "return" to their pre-colonial dressing styles, languages, calendars, flags, and political icons; but metric weights and measures stand still. As illustrations we can mention the former Soviet republic of Azerbaijan, where in 1991 (the very same year of its independence from the USSR), the government decided to stop employing the Cyrillic alphabet and ordered the exclusive use of Latin characters.[31] In other countries there have been attempts to change the calendar in a nationalistic vein, like in Turkmenistan where former president Saparmurat Niyazov promoted a law to change the names of the months, May became Magtymguly (after an eighteenth century Turkmen poet), June was renamed Oguz (honoring Oghuz Khan, considered the founder of the Turkmen nation), etcetera.[32] In Libya—an Italian colony from 1911 to 1951—Muammar Qaddafi also changed the name of the months, for example, February is now "Lights" and August is "Hannibal,"[33] the latter an interesting choice by a Libyan leader, exalting Hannibal's figure, who in the

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[31] Toby Lester, "New-Alphabet Disease?," *Atlantic Monthly,* July, 1997, 20.

[32] After Niyazov's death, and due to popular demand, the old names of the calendar were restituted in 2008. See Paul Theroux, "The Golden Man," *The New Yorker,* May 28, 2007, 57; "Turkmen go Back to Old Calendar," *BBC News,* April 24, 2008, accessed November 3, 2010, http://news.bbc.co.uk/2/hi/asia-pacific/7365346.stm.

[33] Neil MacFarquhar, "Libya Under Qaddafi: Disarray Is the Norm," *New York Times,* February 14, 2001.

third century BC occupied much of the Italian peninsula for fifteen years. Curiously, it was the Italians who implanted the metric system in Libya in 1923, but no anti-metric retaliation was orchestrated by Qaddafi. It is worth noticing then that the metric system has been impermeable to this kind of nationalistic expressions. Apparently the imagined communities of postcoloniality have not incorporated weights and measures into their imagery.[34]

Role of the British Empire

For someone familiar with Great Britain's history it would hardly be a surprise to know that the English opposed the metric system for more than one and a half centuries. It took them 169 years to accept the Gregorian calendar after it was decreed by a papal bull in 1582. Their repudiation of the calendrical reform made Voltaire scoff "The English mob preferred their calendar to disagree with the Sun than to agree with the Pope;"[35] and when they finally adopted it in 1752, riots exploded with people crying "Give us our eleven days!" (eleven was the number of days necessary to synchronize the

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[34] The only exception to this trend (or absense of a trend, rather) that I have heard about is China, where allegedly Mao restituted traditional measures (at least in name, because the magnitudes of those traditional measures were standardized in perfect metric equivalences) as a sign of anti-imperialism and cultural pride. But the sources that claim this are rather dubious ("Li (unit)," *Wikipedia*, accessed September 9, 2010, http://en.wikipedia.org/wiki/Li_%28unit%29; and in Carlos Iglesias, "The Great Wall Under Measurement," accessed November 1, 2010, http://www.cubanow.net/pages/print.php?item=2089) and I have not been able to find any solid references to confirm it. In any case this was a short lived restoration, if it even existed; in 1984 the State Council ordered that the metric system would be the sole legal system in the country after 1990. See Endymion Wilkinson, *Chinese History: A Manual* (Cambridge: Harvard University Asia Center, 2000), 240.

[35] Quoted in Alfred Crosby, *The Measure of Reality* (New York: Cambridge University Press, 1997), 88.

Julian and the Gregorian calendars).[36] England was also the country that stuck the longest with the Carolingian monetary system of 1 pound = 20 shillings = 240 pennies—a system dating from the times of Charlemagne's father—that came to an end in the so called "Decimal Day" (February 15, 1971) that marked the official beginning of decimal currencies in the United Kingdom and Ireland. As today England has been reluctant to enter the zone of the common currency of the European Union, with more than 70 percent of the population opposing the idea of replacing the pound sterling with the euro.[37] And it does not look that Britons will start driving on the right side of the road any time soon (here again going against a French convention initiated in revolutionary France[38]).

This should not be interpreted as a simple "Anglo-Saxon" love for independence and self-determination that is shared by England and America. It is not that England is in a defensive position trying to preserve its culture from foreign attack. That is just a nice self-gratifying portrait that some Britons like to tell themselves and that a few observers have taken at face value.[39] In reality the United Kingdom has not shied away from being an aggressive exporter of its own conventions—their fierce antagonism against the international aspirations of the metric system is a testament to that.

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[36] On this episode see Robert Poole, " 'Give Us Our Eleven Days!': Calendar Reform in Eighteenth-Century England," *Past and Present* 149 (1995): 95-139.

[37] "Most Britons Still Oppose Euro" *BBC News,* January 1, 2009, accessed September 3, 2010, http://news.bbc.co.uk/2/hi/uk_news/7806936.stm.

[38] See H. Peyton Young, "The Economics of Convention," *The Journal of Economic Perspectives* 10 (1996), 105-122.

[39] For example, Linklater, *Measuring America,* 248-258.

In response to France's meter, England undertook in 1824 a comprehensive reform of its own weights and measures that reduced the number of measurement units and greatly improved their technical features, creating with that a system able to compete with the French creation. Not accidentally they called these new measures the *imperial* system.[40] With the expansion of the British Empire during the nineteenth century after the Napoleonic wars, the imperial system started a parallel run to that of the metric system. Since the meter emerged victorious from this clash, historians have focused their attention on the history of the meter, forgetting to tell the story of how the imperial system developed into a global system in its own right (thanks to British military and commercial power). In this connection, the United Kingdom should not be considered as a simple "late adopter" of the metric system; it was rather a challenger struggling to advance a competing system. And England's adoption of the metric system in 1965 meant the defeat of the metric system's biggest competitor.

This does not mean that this conflict had been fought just outside the United Kingdom. In England and other parts of the empire there was political support in favor of metrication. A metric movement in England has existed at least since 1850, with associations like the Decimal Society pushing for adoption of the meter and for decimalization of the currency. And some pressure came also from the periphery of the empire. During the Colonial Conference (an assembly of representatives of the British Empire) celebrated in 1902, New Zealand, Australia, Cape Colony, Transvaal, Orange

[40] On the creation of the Imperial system see Zupko, *Revolution in Measurement,* 176-207.

River Colony, Sierra Leone, Nigeria, and Ceylon demonstrated their support for metric adoption, and the Colonial Premiers passed a resolution favoring the adoption of the metric system for use within the empire.[41] Nevertheless, the British government was not receptive to these demands and the imperial system stayed put until the 1960s (and the big episode in the history of global metrication during the second half of the twentieth century was precisely the transition to metric in the British colonies after their independence).

Overall, it took a little more than a century, but by 1950 the globe was completely divided into two large metrological areas, with all the nations of the world using either the metric or the English system. The rest of the hundreds of measuring systems had been displaced, partially tolerated in specific countries, or simply used underground in local communities. Seen from a larger perspective, the uncanny success of these two systems meant a great loss for humanity's stock of knowledge at large. As the extinction of languages (when local dialects are replaced by a few dominant languages) represents losing entire social funds of knowledge, so the death of local and regional measures has meant the disappearance of collective experience accumulated by hundreds of generations. It is difficult to put in numbers how much has been or is being lost. The few catalogs that exist of units of measurement in the world are extremely incomplete, but they may give us at least a vague idea. A survey made by Federico Beigbeder Atienza in

[41] See the articles on "The Colonial Conference and the Metric System" published in London's *Times*, August 23, 28, 29, September 3, 4, 11, and October 13, 1902. Also, House of Commons. *Papers by Command,* volume 77 (London: Darlyn & Son, 1906), 54; "Weights and Measures (Metric System) Bill," in *The Parliamentary Debates: Fourth Series, Second Session of the Twenty-Eighth Parliament of the United Kingdom of Great Britain and Ireland,* volume 171 (London: Wyman and Sons, 1907), 1313.

the late 1950s listed approximately 793 non-metric, non-imperial units of measurement still in use then around the globe.[42] Another one made a decade later by the United Nations enumerated approximately 898 of those units.[43] It is foreseeable that the majority of those measures will be definitely gone in a matter of decades (in chapter five I will show some of the specific mechanisms of the death of measures). And this loss cannot only be estimated in terms of the number of units that have been swept out by the metric and imperial waves, but also by the antiquity and resiliency of some of the systems that are today forbidden from all official transactions and maybe doomed to disappear from everyday life in the not so distant future (like Japan's shaku-kan system, which was outlawed in 1966 after being used, in a relatively stable form, for a millennium, after its arrival from China in the tenth century).[44]

Decolonization

If colonization was an important factor in global metrication—especially the French colonial regime in the nineteenth century—decolonization was more influential, particularly in the twentieth century following the decline of the British empire in the aftermath of the World War II. The period between 1950 and 2000 (figure 5) was by far the fifty-year span when the most voluntary adoptions of the metric system took place

[42] Federico Beigbeder Atienza, *Manual de pesos, medidas y monedas del mundo con equivalencias al sistema métrico decimal* (Madrid: Castilla, 1959).

[43] Statistical Office of the United Nations, *World Weights and Measures* (New York: United Nations, 1966), 103-130.

[44] Shigeo Iwata, "Weights and Measures in Japan," in *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures,* Helaine Selin, ed. (Boston : Kluwer Academic, 1997), 1021.

(with seventy new adoptions). Two interrelated developments account for this phenomenon: the breakdown of the English control on its overseas dominions, colonies, and protectorates, and the subsequent birth of a large number of new nation-states.

As Wimmer and Min indicate, the period between 1946 and 1975 was one of the most active in the creation of newly formed nation-states after the dissolution of empires.[45] Among these novel nation-states, those using a system other than the metric system decided quickly after independence to make the meter and kilogram their official standards. In that twenty-nine-year window alone sixty-four countries adopted the metric system voluntarily.

More generally, starting with Sudan (that went metric in 1954) and finishing with Saint Lucia (metric by 2000 and so far the latest country to make the transition) all former British colonies that gained independence after 1945—with the lonely exception of Myanmar—switched to the metric system. Some did it the very same year their independence was gained (such as Somalia and Kuwait), others one or two years later (like Cameroon, Nigeria, Swaziland, Qatar, and Brunei). On average these countries went metric seven years after their disengagement from Great Britain.

This whole process speeded up metrication at a pace that had not been seen before. For example, it took European powers eighty-four years (from 1840 to 1924) to metrify half of the current countries in Africa; in contrast, the voluntary adoption of the metric system by the other half, after those nations became independent, took only

[45] Andreas Wimmer and Brian Min, "From Empire to Nation-State: Explaining Wars in the Modern World, 1816-2001," *American Sociological Review* 71 (2006): 872.

twenty-five years, with twenty-four adoptions between 1951 and 1976 (eighteen of them former British colonies).[46]

Once countries gained independence, people interested in the introduction of the metric system saw new opportunities to push their plans forward. In India, for instance, where a movement in favor of decimal coinage and metric weights and measures existed since the beginning of the twentieth century, all attempts in favor of decimalization were blocked because colonial authorities preferred to wait for the United Kingdom to adopt it first. After emancipation groups like the Decimal Indian Society found more receptive ears in the government to attain the reform, that finally came about in 1954.[47]

Another important period for the creation of new nation-states was between 1821 and 1845 (according again to Wimmer and Min), which accounts mainly for the former Spanish colonies in the Americas, which played a decisive but neglected role in the international diffusion of the metric system. Let's see.

Latin America and Metrication

In a way, Latin American countries, which switched to the metric system in the second half of the nineteenth century (see figures 2 and 3), can be considered the first really deliberate adopters of the metric system. Metrication in these nations cannot be

[46] These 24 former colonies are Egypt, Sudan, Madagascar, Burkina Faso, Central African Republic, Gabon, Mali, Somalia, Cameroon, Nigeria, Ethiopia, Namibia, Kenya, Tanzania, Uganda, South Africa, Botswana, Swaziland, Zimbabwe, Lesotho, Ghana, Gambia, Malawi, and Sierra Leone.

[47] Anil Kumar Acharya, *History of Decimalisation Movement in India* (Calcutta: Indian Decimal Society, 1958); Lal C. Verman and Jainath Kaul (eds.), *Metric Change in India* (New Delhi: Indian Standards Institution, 1970).

explained by the historical or geographical factors that I have used to elucidate when and why countries went metric during the nineteenth century.

Latin American countries did not exist yet when the Paris Congress on Definite Metric Standards of 1799 took place (so they were not part of the symbolic creation of the system); they were not France's neighbors (which eliminates the vicinity factor); and they were not French colonies. The big majority of the Latin American countries were voluntary adopters; the only exceptions are Suriname (a French colony) and Cuba and Puerto Rico, that got the meter as an Spanish imposition. In other words, Latin American countries were the first voluntary adopters outside France's military and geographical area of influence and *they made the metric system a truly extra-European reality*.

Figure 2 shows that by 1850 all adopters of the metric system were either France's neighbors or French colonies in Africa. In fact, among the 20 countries that first adopted the metric system after France, 11 were from Latin American (ten of which were voluntary adopters: Colombia, Mexico, Venezuela, Brazil, Peru, Uruguay, Romania, Chile, Ecuador, and Dominican Republic). Who were the other nine? All countries that either participated in the finishing of the metric system during the 1799 conference, or were France's neighbors, or received the metric system by a form of military imposition: Belgium and Luxembourg (neighbors of France and invaded by Napoleon), Netherlands (which had a representative in the 1799 Congress and was invaded by Napoleon), Algeria and Senegal (French Colonies), Spain (France's neighbor, with representatives in the 1799 Congress, and invaded by Napoleon), Portugal (invaded by Napoleon), Monaco (neighbor of France and invaded by Napoleon), and Italy (with representatives in the

1799 conference and invaded by Napoleon). *Latin American countries were not only early adopters, but also the first that went metric free of any form of military coercion* by France or otherwise. They also greatly helped the cause of international metrication by creating, alongside Western Europe, the *critical mass* of countries necessary for the system to be a convincingly multinational and multiregional metrological language. Overall, 16 out of the 35 voluntary adoptions made during the nineteenth century came from Latin America—with Bolivia, Argentina, Costa Rica, El Salvador, Nicaragua, Honduras, and Paraguay doing it during the later decades of the century.

The metric system was actually for more than a century, in terms of voluntary adoptions, a reality contained in Europe and Latin America. Europe's neighbor Turkey (1869) was the only country outside these two regions that adopted the system by its own and did it during a period of increasing commercial exchange with Europe.[48] Besides Turkey we have to wait until 1912-1916 when Siam, China, and Mongolia went metric.[49] In Africa the first voluntary adoption came in 1951 with Egypt.[50] And the first adoption in Oceania did not come until 1969, when Australia and New Zealand decided to follow England into the metric path.[51]

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[48] Feza Günergun, "Introduction of the Metric System to the Ottoman State," in *Transfer of Modern Science and Technology to the Muslim World,* ed. Ekmeleddin Ihsanoglu (Istanbul: Research Centre for Islamic History, Art, and Culture, 1992), 297-316.

[49] In Eastern Asia Japan had passed a law making the metric optional in 1893, but it brought very little penetration, see Iwata, "Weights and Measures in Japan," 1022.

[50] Egypt had actually a long metric past, as the system had been accepted on a permissive basis since 1873, a status ratified in further legislations in 1892 and 1914.

[51] On Australia's path to metrication see, Jan Todd, *For Good Measure: The Making of Australia's Measurement System* (Crows Nest, NSW: Allen & Unwin, 2004).

All this has been greatly ignored by researchers, some of whom have suggested that Latin American countries in the second half of the nineteenth century adopted the metric system simply following Spain's transition in 1849.[52] At first this may look like a plausible assumption since all former Spanish colonies in the Americas began the implementation of their metric plans shortly after that year—starting with Colombia in 1853. But a closer look shows a different picture. Chile, for example, had passed its first metric legislation in 1848 (which made metric units optional); that is a year before Queen Isabel II signed the law to metrify the Iberian nation.[53] Mexico also commenced its own plans for an eventual changeover to the metric system in 1848, and by February 1849 the Mexican Geography and Statistics Society had already presented to Congress a recommendation to make the meter and kilogram the national standards, and later that year the first draft for metric legislation was discussed. Thus, it is more correct to say that metrication plans in Latin America ran parallel to those in Spain. [54]

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[52] See for example, Andro Linklater, *Measuring America* (New York: Walker and Company, 2002), 242.

[53] On the metric system in Spain see Juan Gutiérrez Cuadrado, *Metro y kilo: el sistema métrico decimal en España* (Madrid: Akal, 1997); José Ramón Gómez Martínez, María Teresa Sánchez Trujillano and José Antonio Tirado Martínez, *¿Y esto en onzas cuánto es?: 1853-2003, 150 Aniversario de la implantación del Sistema Métrico Decimal* (Logroño: La Rioja, 2003); Gustavo Puente Feliz, "El Sistema métrico decimal. Su importancia e implantación en España," *Cuadernos de Historia Moderna y Contemporánea* 3 (1982): 95-125; Antonio E. Ten, "El sistema métrico decimal y España," *Arbor. Ciencia, Pensamiento y Cultura* 527-528 (1989): 101-122.

[54] What should be said about Spain's impact in Latin America, however, is that publications by Spanish scientists were highly influential in intellectual circles in the Americas; in particular, the books by the military engineer and mathematician Gabriel Ciscar, one of Spain's representatives to the Paris conference of 1799, served as entrance door for men of knowledge who sought technical literature in Spanish. See Gabriel Ciscar, *Memoria elemental sobre los nuevos pesos y medidas decimales fundados en la naturaleza* (Madrid: Imprenta Real, 1800); *Apuntes sobre medidas, pesos y monedas* (Madrid: Imprenta Nacional, 1821).

For many Latin Americans of the time, embracing the metric system was seen as a way to get closer to the "civilized nations" (meaning mainly Europe), but they did it in many instances more promptly than their role models. This historical irony created apparently paradoxical situations. For instance, when Archduke Ferdinand Maximilian Joseph of Austria arrived to the Americas in 1864, as Maximilian I of Mexico, to head the Second Mexican Empire (with the backing of Napoleon III), he found a country with a complete metric legislation already in place (legislation which he supported) while his native Austria was just starting to experiment in its custom houses with a mixed system of customary measures rounded into metric equivalents (like the *pfund* of half kilogram and the *centner* of 50 kilograms)[55] and fruition of a full-scale plan for metrication was still years in the future. Maximilian—captured and executed in 1867 by the very same Mexican liberals who ten years before had passed the metric legislation in the country—died without seeing a metric Austria.

By looking at the case of Mexico in the following chapters I will try to shed light on the question of why Latin American countries decided to adopt the metric system and why they did so early in the global process of metrication.

When an Irresistible force Meets an Immovable Object:

the Metric System and the United States

[55] On metrication in Austria see Kennelly, 96-101; Hallock and Wade, 86.

As I suggested before, the spread of the metric system through the world was first halted by the United Kingdom by blocking any attempt of metrication within the island and its overseas possessions. By 1950 (see figure 4), the great majority of the countries outside the metric sphere were members of the Commonwealth of Nations, all under British influence. But this levee was broken during the second half of the twentieth century. Today (figure 5), with only seven countries outside the metric ocean (United States, Liberia, Federated States of Micronesia, Palau, Marshall Islands, Independent State of Samoa, and Myanmar), what is characteristic of the metric resistance is its heavy American influence. In addition to the United States, four of the other six non-metric countries were at some point of their history under American administrative control.

Liberia was founded by the Society for the Colonization of Free People of Color of America in 1821-22 and colonized by freed American slaves. It gained its independence from America in 1847, but it still bears numerous marks of the American influence: its capital, Monrovia, was named after American president James Monroe; its currency is the Liberian dollar; its flag shows red and white stripes, as well as a blue square with a white star in the canton. Unfortunately, all my attempts to acquire solid information about the state of metrication in the country have been fruitless.

Palau, Marshall Islands, and the Federated States of Micronesia became United Nations Trust Territories administered by the United States after the defeat of Japan during World War II and gained their independence in the 1980s and 1990s. Reportedly, in these three countries a policy of non-mandatory conversion is currently being undertaken.[56]

As for Myanmar, it is the only former British colony that gained independence after 1945 that did not adopt the metric system (but it is legally accepted, on a non-compulsory basis, since 1920).

The Independent State of Samoa (formerly known as Western Samoa and German Samoa) became independent from New Zealand in 1962. From what I have been able to find out, their non-metric status may have more to do with a lack of state resources than with anything else. In a very telling answer to my inquiries about the state of metrication in the country, a worker in the Ministry of Commerce, Industry, and Labour said that "Samoa has an outdated legislation on weights and measures known as Measures Ordinance 1960. This legislation allows only measures in the imperial system. However, we allow the use of both metric and imperial system during our current trading pending the development of a new weights and measures Act. We have yet to identify financial assistance to assist us with drafting a new bill on measures as there is a lack of expertise around our islands in this field. In the mean time, our Ministry of Commerce, Industry and Labour are able to use the Fair Trading Act 1998 to administer those traders who might be misleading consumers when it comes to weighing goods. If you could add a recommendation in your project for assistance to small island states who are categorized as least developing countries to help finance such important standards in your project that

[56] *The Europa World Year 2004* (London: Europa Publications, 2004), 2835, 2903, 3304.

would be great."[57] Adding to this, the informant detailed how Samoa needs to adhere to testing recommendations set in New Zeeland and Britain for the calibration of petrol pumps and trader scales, for lack of independent Samoan regulations. This alone should be a nice reminder of how crucial state capabilities are for the establishment of metrological homogeneity, and how weights and measures play a role in achieving effective sovereignty (as we will see in the following chapter).

Finally, we have the great enigma of metrication: why is there no metric system in the United States? A country that many people, within and outside America, have waited to see embracing the metric system for more than two centuries. A country that has created some of the more fanatic pro-metric agitators, but also some of the most vicious metric opponents. An ambivalent nation that has helped greatly the metric expansion outside its borders, but that has been reluctant to accept within.

It may come as a surprise to many that the United States was one of the original signatories in the Meter Convention of 1875, a conference that cemented the leading position of the metric system in the world. Also, in the Pan-American Conferences of the 1880s and 1890s the United States supported the plans for a fully metric continent (plans that pushed Latin American nations to complete their metrication processes). It was America who introduced the metric system in the Philippines, when it took control of the islands after the 1898 Spanish-American war. And something analogous happened in

[57] E-mail message to author, June 22, 2010.

Japan, where the metric measures were finally introduced (after failed tries in 1893 and 1921) during the Allied occupation with general MacArthur as Supreme Commander.

Living in a metric world has obliged the United States to make several adjustments and to partially open the doors to the metric system. To mention a couple of examples, during the First World War, American forces faced problems to supply their French allies because the equipment of the Europeans was all metric, what forced the Americas to start manufacturing metric provisions. In addition to this, the General Staff of the Expeditionary Forces in France had to implement the metric system in all their procedures: operation orders, map drawing, firing data for artillery and machine guns, etcetera. Together with these material adjustments instruction in the metric system was given to all military personnel concerned in that front. The Bureau of Standards provided the Army with metric pamphlets, charts, comparison scales, and tables of equivalences; booklets with metric lessons were distributed to the soldiers.[58] In the newspapers of the time some observers claimed—provably too naively—that "had England and America been standardized on the metric system, making instant co-operation with France and the other allies possible, the war would have been shortened by two years."[59]

Peace among nations has also put pressure to the United States to go metric. Influenced by the Olympic Games, in the 1930's the Amateur Athletic Union and the

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[58] Bureau of Standards, *War Work of the Bureau of Standards* (Washington: Government Printing Office, 1921), 220-221; Bureau of Standards, *Metric Manual for Soldiers* (Washington: Government Printing Office, 1918).

[59] Sheldon S. Cline, "Metric System Urged for U. S. and England. Only Two Civilized Nations Retaining Ancient and Cumbersome Weights and Measures," *Evening Star*, June 15, 1919.

athletic programs in several universities converted to the metric system for field events, among other things because "few Americans were numbered among the world's record-holders on the Continent because of the fact that the United States uses the meter only once in four years."[60] The change was effective in track competitions, but not in swimming, due to the inconvenience to replace pools, which usually were 25 or 50 yards in length (the change was not made all at once, though, traditional races such as the Wanamaker mile, the Baxter mile, and the Millrose 600 were still run at the old distances).

But despite all this, in the last instance, the United States has clung tenaciously to its customary measures, which defies all theories and beliefs about the diffusion of metrication. Seen from the point of view of its *national history*, under the assumption that metrication happens "more naturally" after periods of political turmoil, the predictable moments for the adoption of the metric system in the United States (or at least the establishment of a national homogeneous system of measurement, metric or otherwise) were: 1) during the subsequent decades after the revolution of independence, 2) during Reconstruction after the Civil War. Seen from the point of view of *world history*, under the assumption that metrication is often the result of pressure to achieve international coordination and "network homogeny," the key moment for the United States to go metric were the 1960s and 70s, when England and the countries of the Commonwealth kicked out their transitions to metric and left America without metrological partners. As

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[60] "A.A.U. Convention Adopts Metric Plan," *New York Times,* November 23, 1932, 23.

we will see in the coming chapters, in these three historical junctures the United States was close to actually go metric, but the change never came about.

It is my hope that by the end of this dissertation I can offer a satisfactory answer to this American riddle.

3. THE FAILURE OF DECIMAL TIME[61]

Unfortunately, the history of decimal time (especially after the French revolution) has received almost no attention at all from scholars.[62] Its brief existence in actual practice has been dismissed as an extravagant excess of the French revolution. But decimal time ought to be an important topic of research, precisely *because it does not exist*. The absence of a decimal system of time reckoning in a world where decimal numerical notation and decimal divisions for measurement are the norm should have drawn more interest. Here I want to trace the history of decimal time and its fate after the French revolution.

At least since 1585, when the Flemish mathematician Simon Stevin published *De Thiende,* which laid the modern foundations for expressing decimal fractions (even though he did not invent the decimal point as such), the idea of decimalizing coinage and weights and measures had been floating in the air. European scientists and administrators

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[61] This section draws from Hector Vera, "Decimal Time: Misadventures of a Revolutionary Idea, 1793-2008," *KronoScope: Journal for the Study of Time* 9 (2009): 29-48.

[62] One exception is Richard A. Carrigan, Jr., "Decimal Time," *American Scientist* 66 (1978): 305-313, and "Lessons for the Metric System: Decimal Time," in *The Metric Debate,* ed. David F. Bartlett (Boulder, Colorado: Associated University Press, 1980), 99-115; even though he omits crucial events in the history of decimal time.

hoped to implement a comprehensive reform of the systems of measurement that would at the same time standardize the innumerable local measures and coins, and implement a new arithmetic base to facilitate calculations.[63]

During the eighteenth century philosophers and mathematicians started to consider that time should also be part of the overhaul. In 1754, D'Alembert wrote, in the entry "Decimal" in the *Encyclopédie,* that "It would be very desirable that all divisions, for example of the *livre,* the *sou,* the *toise,* the day, the hour, etc. would be from tens into tens. This division would result in much easier and more convenient calculations and would be very preferable to the arbitrary division of the *livre* into twenty *sous,* of the *sou* into twelve *deniers* of the day into twenty-four hours, the hour into sixty minutes, etcetera."[64]

In 1788 a couple of texts advanced more detailed ideas about temporal decimalization. Sylvain Maréchal published *L'Almanach des Honnêtes Gens,* an antecedent of the Republican calendar, that postulated the division of months in three *décades* of ten days each. Also that year appeared *Découverte d'étalons justes, naturels, invariables et universels*, by Claude-Boniface Collignon, that suggested a decimal division of the day, hours, minutes and seconds.[65]

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[63] On the failure of repeated tries to reform the system of measurement prior to the French revolution see Kula, *Measures and Men,* 161-184.

[64] Quoted in Ruth Inez Champagne, "The Role of Five Eighteenth Century French Mathematicians in the Development of the Metric System" (PhD diss., Columbia University, 1979), 145.

[65] Paul Smith, "La division décimale du jour: l'heure qu'il n'est pas," in *Genèse et diffusion du système métrique,* ed. J.-C. Hocquet and Bernard Garnier (Caen: Editions-diffusion du Lys, 1990), 125-126; George Gordon Andrews, "Making the Revolutionary Calendar," *The American Historical Review* 36 (1931): 516.

At that moment in history, however, to eliminate the "arbitrary divisions" of duodecimal and sexagesimal systems in time reckoning and weights and measures, and creating a base-10 system to facilitate the computations made by scientists, was nothing but a dream.[66] The Church kept a tight grip on timekeeping (priests regulated the calendar and church bells were the pacemakers of daily activities). And feudal lords had the right to establish their own weights and measures and were very successful in repelling all attempts made by monarchs to implement a centralized system of measurement (such a reform would decrease their economic power in their own fiefs to the advantage of the central authorities and large scale merchants). Consequently, even if the intellectual basis for the creation of decimal systems of mensuration and reckoning were in place, any realistic plan of reform was impossible due to the religious, political, and economic institutions that controlled time and measures. But the events of 1789 were about to open the door for these plans to finally materialize.

The French revolutionaries aimed for "the decimalization of everything measured or metered."[67] Legislators and members of the Academy of Sciences took very seriously the idea that *all* divisions should be from tens into tens. As part of a plan for a thorough

[66] Only within their own domain, in areas that barely touched everyday activities, scientists could introduce decimals, as Anders Celsius did in 1741 with his temperature thermometer, which separated by 100 degrees the points of reference of his scale (the freezing and boiling points of water). This was a marked departure from the previous scales by Roemer and Fahrenheit, both based on a sexagesimal system, see Herbert Arthur Klein, *The Science of Measurement* (New York: Dover, 1988), 295-321.

[67] John L. Heilbron, *Weighing Imponderables and Other Quantitative Science Around 1800* (Berkeley: University of California Press, 1993), 249.

restructuration of all methods of measurement they redesigned customary weights and measures, the circumference, money, and time to fit into the decimal grid.[68]

Reforming a system of measurement involves changing one, two or all the nuclear elements of the system to be modified:

- the units of measurement (their magnitude, size, or amount),
- the names of the units,
- and the system of grouping and division (like base-10 or base-12, for example).

All combinations can take place in changing these elements. It is common that a unit varies in its magnitude but keeps its name and subdivisions (like adjusting the *size* of the inch). Also common is that a unit changes its magnitude and multiples but keep its name (e.g. the decimal American *dollar* that replaced the eight-*real* Spanish *dollar*). And there have been some particularly radical reforms that change the three elements at once, like the one that the French aimed in the 1790s. They decided to create units with new magnitudes, provided an *ad hoc* nomenclature for those units, and obliterated duodecimal, hexadecimal, and sexagesimal divisions in favor of the decimal system. Their objective was not only to improve scientific procedures; they actually sought to reorganize social life by rationalizing weights and measures, money, and the calendar—in other words, standards that regulate economy, political administration, and everyday life.

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[68] On decimalization as a general tendency during the revolution, see Ken Alder, *The Measure of all Things* (New York: The Free Press, 2002), 125-159; Denis Guedj, *El metro del mundo* (Barcelona: Anagrama, 2003), 141-157; Kula, *Measures and Men,* 250-251.

First was the modification of weights and measures. A reform in this area had been demanded for a long time and was one of the most common topics of complaint (especially by the third estate) in the lists of grievances collected for the Estates-General of 1789.[69] Plans for a metrological overhaul started the summer of that year and culminated in 1795 with the creation of the decimal metric system, an elegant scheme with three interrelated basic units—meter, liter, and gram—that replaced hundreds of local measures that coexisted in a disorganized fashion all around France. The new units were decimally divided using a set of prefixes to multiply (deca-, hector-, kilo-) or divide (deci-, centi-, milli-) the measure by a factor of ten. The election of decimals was a particularly radical option, because people in general were not familiar with decimal fractions and the use of the decimal point, something that created numerous complications for the popularization of the system. This plan, nevertheless, served as the blueprint for the other projects.[70]

The currency reform was the second in the list and concluded with the creation of the *franc* in 1793,[71] which replaced the *Louis d'or,* the *écu* and other monetary units. The franc was divided into 10 *decimes* and 100 *centimes*. A very similar scheme had been put

[69] Kula, *Measures and Men,* 185-227.

[70] On the project of decimalization of weights and measures see Champagne, "The Role of Five Eighteenth Century French Mathematicians," 141-156.

[71] Adrian Tschoegl, "The International Diffusion of an Innovation: The Spread of Decimal Currency," *Journal of Socio-Economics* 39 (2010): 105.

in place just recently in the United States, following a plan by Thomas Jefferson, with the dollar fractioned into 10 dimes and 100 cents.[72]

The third reform was the creation of a new calendar and time-reckoning system, also known as the Republican calendar. Since much has been written about it, there is not necessity to describe the French calendar in great detail here.[73] But a brief look at its architecture is instructive to see how its designers decimalized it.[74]

The revolutionaries kept the year of 12 months, but instead of the irregular months of the Gregorian calendar (varying from 28 to 31 days of duration) they decided to have a more symmetrical division, with months of 30 days each. Given that this only accounted for 360 days, the five extra days required to approximate the solar year were placed at the end of each year without being count in any month. The calendar marked the beginning of a novel period in human history, the Republican era, and they set day

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[72] See C. D. Hellman, "Jefferson's Efforts towards Decimalization of United States Weights and Measures," *Isis* 16 (1931): 266-314.

[73] Of especial interest among the large body of literature on the republican calendar: Eviatar Zerubavel, "The French Republican Calendar: A Case Study in the Sociology of Time," *American Sociological Review* 42 (1977): 868-877; Andrews, "Making the Revolutionary Calendar," 515-532; Baczko Bronislaw, "Le calendrier républicain," in *Les lieux de mémoire,* ed. Pierre Nora (Paris: Gallimard, 1997), 67-106; James Friguglietti, "The Social and Religious Consequences of the French Revolutionary Calendar" (PhD diss., Harvard University, 1966); also by Friguglietti, "Gilbert Romme and the Making of the French Republican Calendar," in *The French Revolution in Culture and Society,* ed. N. Andrews (New York: Greenwood Press, 1991), 13-22; Mona Ozouf, "Revolutionary Calendar," in *A Critical Dictionary of the French Revolution,* ed. F. Furet and M. Ozouf (Cambridge, Mass.: Harvard University Press, 1989), 538-546; and Matthew John Shaw, "Time and the French Revolution, 1789-Year XIV" (PhD diss., University of York, 2000).

[74] For works focused on the decimalization of time in the French revolution: Paul Smith, "La division décimale du jour," 123-134; Louis Marquet, "24 heures ou 10 heures? Un essai de division décimale du jour (1793-1795)," *L'Astronomie* 103 (June 1989): 285-290; Shaw, "Time and the French Revolution," 93-100.

one of this new epoch on September 22, 1792, the day when the French republic was proclaimed, after the abolition of the monarchy.

Months in the calendar were "divided into three equal parts, of ten days each, called *décades,* and distinguished from one another as first, second, and third."[75] The day was divided into ten parts or hours, each part into ten others, and "so on up to the smallest measurable portion of duration."[76] The hundredth part of the hour was called *decimal minute*, and the hundredth part of the minute *decimal second*.

With this diagram all divisions of time, from the month to the second, were decimal, which implied the challenge to replace two different sets of "old" time units. On the one hand, the ten-day *décade* was meant to substitute the seven-day week (10 vs. 7); very important here was the elimination of Sundays as a day or rest, in favor of the *décadi*, the tenth of the *décade*. On the other hand, the decimal day had to replace the twelve-hour day with its "ante meridiem" and "post meridiem" periods (10 vs. 12), and the decimal hour had to take the place of the hour of 60 minutes and 60 seconds (10 vs. 60).

The decimalized day, hour, and minute survived just 17 months (from November 24, 1793 to April 7, 1795), and was barely used in practice. Some clocks and timepieces were manufactured to display decimal time,[77] but the whole plan was buried before it had

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[75] "Decree Establishing the French Era, November 25, 1793 (4 Frimaire, Year II)," in *A Documentary Survey of the French Revolution,* ed. John Hall Stewart (New York: Macmillan, 1951), 509.

[76] "Decree Establishing the French Era," 509, 512.

[77] Numerous pictures and descriptions of decimal clocks can be seen in *Les heures révolutionnaires,* ed. Yves Droz and Joseph Flores (Besançon: Association Française des Amateurs d'Horlogerie Ancienne, 1989).

any chance to fly. Among the reasons adduced to suspend the proposal were the high costs of replacing clocks and watches, and popular confusion due to the novelty of the decimal units—not very convincing arguments considering that the metric system faced the same adversities, and was pushed through nonetheless. More persuasive was the argument that counting hours was not a commercial activity susceptible of police regulation and the old practices would continue "due to the immense force of habit"[78] (this was an implicit acknowledgment that these reforms had to be introduced more by state force than by the popular agreement).

The rest of the calendar, including the *décade,* persisted 12 years (from 1793 to 1805). The new ten-day "week" was the most controversial element of the whole calendar. It represented a disruption of the rhythms of commerce, festivities, and labor, and a direct confrontation against religious practices.[79] Even if dechristianization was not necessarily the primary objective in the mind of the designers of the Republican calendar, it certainly became an antireligious weapon in the hands of the most radical sectors of the revolution.[80] The entire experiment produced mixed results. Some embraced enthusiastically the new calendar, but in general it created confusion and many people simply kept using the "old" calendar and week. At the end, Napoleon restored the Gregorian calendar and the seven-day week as part of his reconciliation with the Church.

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[78] See Marquet, "24 heures ou 10 heures?," 287.

[79] On the social consequences of eliminating the seven-day week (and Sundays) see Eviatar Zerubavel, *The Seven Day Circle: History and Meaning of the Week* (New York: The Free Press, 1985), 27-35.

[80] Friguglietti, "Gilbert Romme," 18-19; Ozouf, "Revolutionary Calendar," 541.

As one can see, the three major decimal reforms of the revolution ended having very different fates in France. The metric system is not only still employed in France but it is universally used in the world. The franc lasted until 2002, when another decimal currency replaced it, the euro. And the Republican calendar was never broadly used and survived little more than a decade. (See Figure 7.)

Figure 7. Measurement Systems Before, During, and After the French Revolution

	Old Regime Measures	**Revolutionary Measures**	**Duration of Revolutionary Measures**	**Current Measures**
Day, hours and minutes	24-hour day, hour of 60 minutes, minute of 60 seconds	10-hour day, hour of 100 minutes, minute of 100 seconds	2 years (1793-1795)	24-hour day, hour of 60 minutes, minute of 60 seconds
Calendar	Gregorian calendar	Republican calendar	12 years (1793-1805)	Gregorian calendar
Money	*Louis d'or*, and others	Decimal *franc*	207 years (1795-2002)	*Euro* (decimal)
Weights and measures	Medieval weights and measures	Decimal metric system	214 years… (since 1795)	Decimal metric system

The three decimal systems of measurement and reckoning had also opposite fortunes outside France. Decimal time was not used in other countries. On contrast, today approximately more than 99 per cent of the people in the world live in countries that use exclusively decimal currencies (excepting Madagascar and Mauritania); and roughly 95 per cent of the world population lives in countries where the decimal metric system is the only legal system of weights and measures (Liberia, Myanmar, and the United States are the only nations outside the metric sphere). In the final section of this article some hypotheses are suggested to explain why contrary to the global success of the metric system and decimal currencies, plans for a fully decimalized time system were never accepted. But before that we will see what happened to decimal time *after* the French revolution, a topic that has received very little attention by historians.

The interest in decimal time from the heydays of Napoleon to the 1870s was erratic to say the least. In 1856 appeared *The Decimal System as a Whole*, a sole pamphlet written by a Liverpool watchmaker, Richard Dover Statter, which applauded the advantages of a base-10 system of time reckoning.[81] And there are reports that in 1870 the subject was addressed before the Paris Academy, by the astronomer Antoine-Joseph Yvon Villarceau and other scientists.[82] But these discussions did not get any traction, and decimal time looked at that point as alive as the Egyptian calendar.

But the international debates surrounding the creation of a global standard of time reference—which culminated in the International Meridian Conference of 1884—renewed the interest of scientists and government officials around the world on prospects for utilizing a decimal time system, and also gave France a fresh opportunity to try to expand decimals to the realm of time measurement.

In the second half of the nineteenth century the railroad and the telegraph compressed time and space and with that appeared the need for a uniform time standard. These new means of communication and transportation required a single timetable to coordinate communities that up to that point had been regulated by their own local time.

[81] See Carrigan, "Decimal Time," 309.

[82] "The Decimal Division of Time and Angles," *Science* 4 (1896): 871.

That was the practical basis for the creation of standard time zones.[83] And the growing need to follow strict schedules and regulate social activities with more punctuality actually made decimal time more pertinent than before, because people had to make more complicated time calculations on a daily basis.[84]

The Canadian engineer Sandford Fleming is usually credited for the invention of the standard-time zone system—to which he certainly contributed greatly. But parallel to Fleming's work, a group of experts congregated in the American Metrological Society (AMS) developed a similar plan. Actually, when Fleming received no help from England (Canada was then a British dominion) to promote his scheme, the AMS backed him up. The president of the Society, F.A.P. Barnard, successfully lobbied the American government to host an international conference to fix a common prime meridian, and in 1882 president Chester Arthur invited the governments that held diplomatic relations with the United States to be part of a conference in Washington in 1884.[85]

Since its creation in 1873, decimalization had been an important subject matter in the AMS. From the 1870s to the 1890s the society mounted several campaigns to secure legislation in favor of the complete adoption of the metric system in the United States.

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[83] Eviatar Zerubavel, "The Standardization of Time: A Sociohistorical Perspective," *The American Journal of Sociology* 88 (1982): 7.

[84] Actually, it was reported that in certain parts of Italy and India there were quadrants of railroad clocks that were divided into 100 minutes, "The Decimal Division of the Circle," *Architecture and Building* XXVIII (April, 1898), 118.

[85] The *Proceedings of the American Metrological Society,* from 1873-1888, include the reports of the Committee on Standard Time and other related articles. On the role of the AMS on time standardization, see Ian Bartky, "The Adoption of Standard Time" *Technology and Culture* 30 (1989): 25-56; Peter Galison, *Einstein's Clocks, Poincaré's Maps* (New York: Norton, 2003), 113-128. On the relation between Fleming and the American Metrological Society see Clark Blaise, *Time Lord: Sir Sandord Fleming and the Creation of Standard Time* (New York: Vintage, 2000), 130-132, 180-186.

And one of the most active members of the Society was the young librarian Melvil Dewey, fervent supporter of the metric system and creator of the Dewey decimal system of library classification. Dewey's design uses decimals to organize all human knowledge by arranging books in a specific and repeatable order with 10 main *classes,* each consisting in 10 *divisions,* and each division with 10 *sections*, all of them with a pre-assigned number. Each field of knowledge and discipline have a traceable place arranged within a clear framework. Alongside Jefferson's decimalization of currency, Dewey's classification has to be considered one of the most significant contributions of America to decimalization.

The opportunity of having a decimal time system was also addressed by the members of the AMS. In 1879 Frederick Brooks published a paper on "The Division of the Day," where he advocated for a decimal partitioning of the day and showed a good deal of optimism on the eventual disappearance of duodecimal systems:

"[The] division by twelve has no more to do with natural phenomena than the division of the zodiac into twelve signs. Twelve is a convenient mathematical quantity and has therefore been much used. Small wares are sometimes sold by the dozen and gross, and were formerly paid for in shillings and pence: but twelve pence in the shilling is getting to be obsolete, many goods are now sold by the hundred, and the introduction of the Metric System of weights and measures will naturally suggest the thought of a decimal system of measuring time. […] the hour with its customary sub-division into 60 minutes or 3600 seconds, will be regarded as a case of arrested development, a monstrous feature on the face of our metrology."[86]

Apparently the other members of the society did not discard the idea of a decimal time system, but they were not as enthusiastic as Brooks, and the AMS did not push the topic any further—something understandable considering that it had its plate already full with the metric and the prime meridian campaigns.

Heading into the 1884 conference in Washington, some discussions were advanced in the General Conference of the International Geodetical Association, held at Rome in 1883. Besides dealing with the problem of a prime meridian meridian, the subject of the decimal system of dividing the circle and time was "received with unanimity,"[87] but no concrete action was taken to achieve that purpose. The following year the topic was debated again.

The International Meridian Conference brought together delegates from thirty countries "for the purpose of fixing upon a meridian proper to be employed as a common zero of longitude and standard of time-reckoning throughout the globe," and it was in many ways a confrontation between England and France for world scientific supremacy. The main purpose of the French delegation was to avoid the adoption of the Greenwich meridian as the international meridian for longitudes. But that was a lost battle from the

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[86] Fredek. Brooks, "The Division of the Day," *Proceedings of the American Metrological Society* II (1979): 4.

[87] This according to General Richard Strachey, one of Great Britain's delegates at the Washington conference, *International Conference Held at Washington for the Purpose of Fixing a Prime Meridian and a Universal Day, October, 1884: Protocols of the Proceedings* (Washington, D.C.: Gibson Bros., 1884), 185.

beginning. The majority of the countries represented at the conference, leaded by the English and Americans, supported the selection of Greenwich. Defeated in that front, the French moved to plan B: if France was to accept the British meridian, the England had to correspond by adopting the decimal metric system.[88] This reciprocation was suggested in several occasions during the meetings, but the adoption of systems of weights and measures was not part of the topics established for the conference and was ruled out.

The final resource of the French delegates, who were systematically beaten in all their proposals, was to use the Conference to advance the use decimal time among scientists. The astronomer Pierre Jules in a plea to the delegates to adopt decimal time said that

> at the time of the establishment of the metrical system the decimal division had been extended to the measurement of angular space and of time. […] As to time, the reform was introduced too abruptly, and, we might say, without enough discretion, and it came into conflict with old habits and was quickly abandoned; but as to the division of angular space, in which the decimal division presented many advantages, the reform sustained itself much better, and is still used for certain purposes. […] It is, therefore, now evident that the decimal system, which has already done such good service in the measurements of length, volume, and weight, is called upon to render analagous services in the domain of angular dimensions and of time. […] if we failed at the time of the Revolution, it is because we put forward a reform which was not limited to the domain of science, but which did violence to the habits of daily life. It is necessary to take the question up again, but with due regard to the limits which common sense and experience would prescribe to wise and well-informed men. I think that the character of the reform would be well

[88] Spaniards and Italians supported the French in this *quid pro quo*, see *International Conference,* 88.

defined by saying that it is intended especially to make a new effort towards the application of the decimal system in scientific matters.[89]

In addition to this request, the renowned geologist Alexandre-Emile Béguyer de Chancourtois sent to each delegate a detailed proposal "to supersede the present mode of measuring both angles and time by a system in which the entire circumference and the length of the day should each be first divided into four equal parts, and then each of these parts should be subdivided decimally." And J. P. Merritt, from Ontario, sent a letter to the Conference recommending "redistribution of time according to the decimal system." No scientific arguments were voiced to oppose these ideas, and even John Couch Adams, director of the Cambridge Observatory, recognized that "for certain purposes, the decimal division of the circle is very valuable."[90] But there were objections in the direction that those propositions were not within the limits received by the delegates from their respective governments.

At the end an agreement was reached: no punctual actions to implement decimal time would be suggested, but further reflection on the matter was encouraged. In this line, the seventh resolution of the meeting reads, "that the Conference expresses the hope that the technical studies designed to regulate and extend the application of the decimal system to the division of angular space and of time shall be resumed, so as to permit the

[89] *International Conference*, 183-184.

[90] *International Conference*, 153-156, 186.

extension of this application to all cases in which it presents real advantages."[91] It was a political compromise, but some years later new technical studies indeed appeared.

In the Sixth International Geographical Congress, held in London in 1895, decimal time became again a theme of debate. Three different projects were expounded: those of Joseph de Rey-Pailhade and Henri de Sarrauton on behalf of the Geographical Society of Toulouse and the Oran Geographical Society, respectively; and Joaquín de Mendizábal y Tamborel, representing the Sociedad Científica Antonio Alzate, from Mexico.[92] All of them were keen to the idea of decimalizing time, but they differed on what was the most appropriate way to do it.

Rey-Pailhade (1850-1934) deserves an especial mention in the history of decimal time. He was a French mining engineer and doctor, who did much to maintain the international attention over decimal time from the 1880s to the 1910s. He was the president of the Comité pour la Propagation des Méthodes Décimales, in charge of disseminating information among scientific and commercial circles about the possible applications and advantages of decimal methods. He worked restlessly in favor of chronological decimalization and advanced the cause in three different areas: designing a system of decimal division of the day, divulgating news about decimal time for the larger public, and contributing to the study of the history of decimal time (his labor of

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[91] *International Conference*, 203.

[92] For a detailed account of these plans see the report by the Vice President of the Congress, Rafael Torres Campos, *La geografía en 1895. Memoria sobre el VI Congreso Internacional de Ciencias Geográficas celebrado en Londres* (Madrid: Fortanet, 1896), 36-64.

documentation, held in the municipal library of Toulouse, consists of 73 volumes!).[93] The essence of Rey-Pailhade's project in the London Congress was to divide the day into 100 *cés* (abbreviation of *centijour*) and use decimal subdivisions, *centicés* (a one hundredth of cé) and *dimicés* (a ten thousandth of cé).[94]

Sarrauton's system presented a key difference with that of Rey-Pailhade, instead of decimalizing the day, it conserved the 24-hour day and only the hour would be divided (into 100 minutes and 10,000 seconds). Sarrauton did not want to make tabula rasa of the past and recognized the established place of the hour (i.e. the twenty-fourth part of the day) as a universally accepted unit. He tried in that way to avoid a permanent divorce between the general public and the savants, but still have some of the advantages of decimals.[95]

In Mendizábal y Tamborel's proposal the basic unit was the sidereal day, that he called *tropo* (from the greek *tropos,* "a turn"), with multiples of *decitropo*, *centitropo*, and *microtropo*. Contrary to Sarrauton, the Mexican geographical engineer was of the opinion that the new chronological regime had to cut sharply from previous systems. The

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93 Rey-Pailhade produced an industrial quantity of writings on decimal time. See for instance *Le Temps décimal, avantages et procédés pratiques, avec un projet d'unification des heures des colonies françaises* (Paris: Gauthier-Villars, 1894); "L'application du systeme décimal a la mesure du temps et des angles," *Revue Scientifique* 32 (1895): 315-316; "Le temps décimal a Toulouse pendant la Révolution,"*Bulletin de la Société de Géographie de Toulouse* 18 (1899): 534-541.

94 Rey-Pailhade, "Simultaneous and Parallel Application of Decimal Arithmetic to the Measure of Time and Angles," in *Report of the Sixth International Geographical Congress* (London: John Murray, 1896), 255.

95 Campos, *La geografía en 1895*, 54-62. Sarrauton also wrote several articles on decimal time, see for example, "L'heure décimale," *Revue Scientifique* 34 (1897), 201-210.

experience provided by the metric system, he said, had shown that a definitive break with the ideas of the past was the most effective way to introduce the reform to the public.[96]

At the end all these proposals did not amount to much in the Congress and only a less than warm resolution was obtained: "The Congress request the Geographical Societies represented at it to consider the question of application of the decimal system to angular and time measurements, and to report on the subject to the next Congress."[97] Once again scientists did not openly oppose the idea of decimalizing time, but they were not interested in backing it fully.

To make things worse for the members of the decimal camp, in the last two decades of the nineteenth century a number of articles in opposition to decimalization in general and decimal time in particular appeared in different English-speaking countries. Among them was a series of opinion-editorials by Herbert Spender, published in *The Times,* in 1896[98]—that where widely read in both sides of the Atlantic—and also publications by lesser-known figures, like the Canadian R.E.W. Goodridge, who wrote a pamphlet *On the Proposed Change of Time Marking to a Decimal System: A Plea that the Duodecimal System be Retained*.[99]

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[96] Campos, *La geografía en 1895,* 53-54; see also Joaquín de Mendizábal y Tamborel, "La división decimal del ángulo y del tiempo," *Boletín de la Sociedad Mexicana de Geografía y Estadística* III (1895): 490-492, and Amado A. Chimalpopoca, "División decimal de la circunferencia," *Boletín de la Sociedad Mexicana de Geografía y Estadística* III (1895): 484-489.

[97] *Report ... International Geographical Congress*, 785-786.

[98] These articles were collected in Herbert Spencer, "Aginst the Metric System," in *Various Fragments* (London: Appleton, 1914), 142-170, 225-239.

[99] Winnipeg: Manitoba Daily Free Press, 1886.

At this juncture it was clear that some political muscle was needed to pull a reform through, and the French government was willing to lend a hand. In 1896 the Minister of Public Instruction instructed the Bureau of Longitude to study the pertinence for France of adopting decimal time and abandoning the customary time system. The Bureau of Longitude had been founded in 1795—ironically the same year that the decimal day and hour were suppressed—to perfect and develop nautical navigation, standardization of time-keeping, and astronomical observation. Actually, many of the scientists who participated in the design of the metric system and the republican calendar were founding members of the Bureau, like Delambre, Méchain, Lagrange, Laplace, and Borda.

To carry on the study solicited by the Minister, the president of the Bureau appointed in 1897 a Commission of Time Decimalization, with the renowned mathematician Henri Poincaré as its secretary. If some of the major mathematicians of the eighteenth century were not able find an effective plan to decimalize time, probably one of the major mathematicians of the nineteenth century would do it.[100]

The work of the Commission was not smooth. Its members clashed on how drastic a possible reform should be and whether prevalent chronological conventions should be obliterated or left intact—in many ways resembling the debates that took place in the London congress. The more radicals in the Commission sought the full decimalization of the day, hour and minute. Putting that plan in practice, however, not

[100] Galison, *Einstein's Clocks, Poincaré's Maps,* 162-174 provides a detailed account of the debates that took place in the Commission and the role of Poincaré on it.

only would create discontent among the people, but it would also require significant changes in standards and instruments for navigation, the electrical industry, railroad systems, and the like. As Poincaré stated looking for an intermediate position, "we cannot break completely with the past, because not only must we take account of public repugnance, but scientists themselves have a tradition to which they remain tide."[101]

In a negotiated solution the Commission concluded to divide the day in 24 hours and to decimalize the hour and its subdivisions; to have a circumference of 400 degrees with the degree decimally subdivided; and to find approval for this scheme in an international congress.[102] But this compromise left many unhappy in the Commission and failed to generate support at the international level. The whole adventure ended with the Ministry of Foreign Affairs informing the Bureau of Longitude that the government will not sponsor the plan.[103]

Finally, in 1899 two members of the French Chamber of Deputies, Gouzy and Delaune, introduced a proposal for a law to divide the day into 24 hours, the hour in 100 minutes, and the minute in 100 seconds, but it never passed.[104] Thus, at the start of the new century the last official attempts to decimalize time in France came to nothing.

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[101] Quoted in Galison, *Einstein's Clocks, Poincaré's Maps*, 165.

[102] Henri Poincaré, "Rapport sur les résolutions de la commission chargeé de l'étude des projects de décimalisation du temps et de la circonférence," in *Oeuvres de Henri Poincaré* (Paris: Gauthier-Villars et Cie, 1952), 8: 664, see also in that volume "La décimalisation de l'heure et de la circonférence," 676-679.

[103] Galison, *Einstein's Clocks, Poincaré's Maps,* 173.

[104] Marquet, "24 heures ou 10 heures?," 290; Carrigan, "Decimal Time," 309.

For decades little happened with decimal time after the last French push in the 1890s. Only occasional petitions were published here and there,[105] but no serious plan was articulated. However a significant development occurred in 1960, with the formal integration of time with the other decimal systems of measurement, when the General Conference on Weights and Measures unveiled the International System of Units (SI). The SI is the present name of the metric system. Originally, the metric system had three base units: meter (length), liter (volume), and gram (mass). For everyday life purposes this system is pretty much intact, but it has suffered many alterations and additions in the scientific world. Today the SI has seven base units: meter (length), kilogram (mass), second (time), ampere (electric current), kelvin (thermodynamic temperature), candela (luminous intensity), and mole (amount of substance).

All these units use the SI prefixes to denote decimal subdivisions, including the second. Thus microsecond means one millionth of a second, nanosecond one billionth of a second, and so forth with pico-, femto-, atto-, zepto-, and yoctosecond, the latter being one septillionth of a second. In theory, with these prefixes now it is possible to use decimal terms to express spans larger than the second, like kilosecond (one thousand seconds) or megasecond (one million seconds), but these multiples are not actually used.

As a result, today we are decimal in the larger and smaller units of time reckoning. Years are decimally grouped in decades, centuries and millennia; and seconds are divided in groups of ten using the prefixes of the SI. Thus, from the year up time units

[105] See for example Frank J. Moles, "An Auxiliary System for the Measurement of Time," in *The Metric System of Weights and Measures: The National Council of Teachers of Mathematics* (New York: Teachers College, 1948), 225-233.

increase decimally, and from the second down they decrease decimally as well. What do we have in between? The year divided in 12 months; months divided in 28, 29, 30, or 31 days; the seven-day week; days divided in either 24 hours or two sets of 12 hours (depending if one uses the 24-hours clock or the AM/PM designation), the hour of 60 minutes, and the minute of 60 seconds. Strikingly, our modern-scientific civilization regulates its temporal life following a "system" that combines decimal, duodecimal, and sexagesimal systems.

Near the end of the last century new technological developments opened the door again for decimal time. If the railroad and the telegraph created the necessity for uniform standard time and time zones, the newest revolution in communications may challenge some of the principles of the temporal arrangement established in the 1880s.

In 1998 Swatch Group, the Swiss timepiece manufacturer, launched what they called Swatch Internet Time, or "beat time." This system allows people in different parts of the planet who are simultaneously connected through the internet to use a single global time without time zone differences (and without daylight saving time). Swatch's scheme removes time zones altogether by establishing an Internet Time meridian or Biel Meantime (BMT), that takes its name from Swatch's headquarters in Biel, Switzerland (even though a day in internet time actually begins at midnight Central European Winter time).

Swatch Internet Time divides the day into 1000 ".beats." Midday, for examples, means 500 beats (expressed @500) and takes place concurrently in Nairobi, Kabul, Denver, or anywhere else in the world. According to the company "Internet Time exists so that we do not have to think about timezones. For example, if a New York web-supporter makes a date for a chat with a cyber friend in Rome, they can simply agree to meet at an "@ time"—because internet time is the same all over the world."[106]

Despite its potential as a standard to coordinate the massive amount of activities carried out daily through the internet around the globe, Swatch Internet Time has not been very successful and it is only used in limited areas. However, it is based on the legitimate premise that the internet works at the same time all over the world without having to conform to geographical particularities and is then free to ignore time zones, seasonal adjustments, and national conventions. Of course, internet time does not have to be decimal (it can pretty well follow the usual 24-hour day and 60-minute hour and keep fulfilling the same function), but it is worthy of note that its makers chose to divide the day in a thousand parts, probably to emphasize its novelty.

In 2008 David Chanson, grandson and great-grandson of Swiss watchmakers, launched a series of peculiar wristwatches that instead of having a 12 hours dial, are fractioned into 10 *divides*, and each *divide* is decimally divided as well. Chanson argues that the decimal system that inspired his timepieces is more logical than the current division of 60 minutes and 60 seconds. He considers that for people to accept decimal time it would require a period of adaptation, but it is not, he says, an insurmountable effort, and compares it with the introduction of the metric system in England and the euro in the European Union.

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[106] "Swatch Internet Time." Swatch Group. http://www.swatch.com/zz_en/internettime.html.

Even if so far the only buyers of these decimal watches have been collectors (and there are no signs of interest among the general public), newspapers around the world reported on Chanson's creation with a mixture of surprise and admiration. In Australia it was said that the Swiss designer is "ahead of his time," and in Spain that "Chason invented the clock of the twenty-first century."[107] Curiously, decimal time is an idea that has been considered since the end of the eighteenth century and was temporarily utilized during the French revolution. And contrary to Chanson's optimism, history tell us that changing our system of time reckoning has proven to be a much more intricate task than the decimalization of currency and weights and measures.

[107] "Swiss Designer's 'Logical' Watch Is Ahead of its Time," *The Canberra Times,* December 29, 2008; "David Chanson inventa el reloj del siglo XXI," *Noticiasdot.com*, December 31, 2008.

CHAPTER II

Measuring Like a State:
Sovereign Power and the Monopoly on the Legitimate Means of Measurement

> Geometricians and algebraists were consulted upon a question which was of *administrative jurisdiction*. They thought that the unit of weights and measures should be deduced from a natural constant, so that it might be adopted by all nations. They thought it was not enough to provide for the advantage of forty million men; they wanted the whole universe to participate in it.[1]
>
> *Napoleon Bonaparte*

> The Conqueror of our days, whether peoples or princes, wish their empire to present an appearance of uniformity, upon which the proud eye of power may travel without meeting any unevenness that could offend or limit its view.[2]
>
> *Benjamin Constant*

Introduction

If one is asked to point out the single most important factor to explain how metrication was possible—in the sense of both a system that approximately 95 per cent of the world population actually use in their everyday activities—the answer should be that it was possible mainly as a result of nation-states adopting, regulating, and enforcing the metric system. In this chapter I want to show why modern nation-states have been vital for metrication. Also, I intend to explain why states took an especial interest in controlling weights and measures (or establishing what I call a *monopoly on the legitimate means of measurement*) and what kind of benefits states obtain from this

[1] *Memoirs of the history of France during the Reign of Napoleon, Dictated by the Emperor at Saint Helena* (London: Henry Colburn and Martin Bossange, 1824), IV: 201.

[2] *Political Writings* (New York: Cambridge University Press, 1988), 73-74.

control. In other words, my aim in this chapter is to show that *modern nation-states need metrication and metrication needs the states*.

States need metrication because the uniform establishment of the metric system gives states leverage to fulfill some its essential functions: undermine the influence of local authorities; enhance the extraction of revenue; consolidate an internal market; make the population and the economic resources "legible"; monopolize symbolic capital; reduce commercial frauds (then heightening the administration of justice); share standards of science and commerce with other countries; and introduce leveling, homogenizing institutions that aid the creation of a common national "spirit" or experience.

Metrication needs the state. As Theodore Porter stresses, standard measures and uniform classifications are as beneficial for centralized governmental activity as they are for large-scale trade; precise, uniform measures "enhance administrative control over matters of taxation and economic development. At the same time, an impressive display of state power [is] required to enact the new [measurement] system in the first place."[3] Only modern states have shown to be effective in helping, compelling, and, if necessary, forcing people to learn and employ metric units—i.e. to *think* and *act* metric. Science alone cannot do that, neither large-scale commerce and industrialization. And populations by themselves have never done it. Full metrication can only be achieved when two actions are combined: 1) policing the employment of metric units; 2) providing

[3] Theodore Porter, *Trust in Numbers* (Princeton: Princeton University Press, 1995), 26.

populations with the intellectual and material means to learn the metric language. As the case of the United States shows, the effectiveness of science and industry to instill a metric way of thinking among the population at large is rather limited. Medicine in America, for example, has been metric for more than a century, and doctors write prescriptions for patients detailing doses in milligrams and milliliters, but that, however, has not obliged people to think primarily with those units. Full metrication, in other words, requires *compulsion*—and compulsion is essentially a political issue, an issue of the state.

Full metrication, as it is understood here, does not mean that a select group of people is fluent in using metric terms and decimal arithmetic (no matter how influent that group is within a specific society). It does not mean either that a large part of the population of a country has some notions of what the metric system is. Full metrication—which in many ways is the really fascinating phenomenon in the history of the metric system—means that the entire population (or almost) of a given territory orient themselves in the world primarily using the concepts and logic of the decimal metric system when it comes to apprehend their own selves and their environment in terms of quantities for length, volume, and weight.

In what follows I will explore how the United States and Mexican states dealt with the establishment of a monopoly on metrological matters—and with the metric system in particular. But first some historical and theoretical considerations are necessary.

1. STATE AND MEASUREMENT: SOME HISTORICAL AND THEORETICAL CONSIDERATIONS

The tomb of Meketre[4] contained, in a hidden chamber, several wooden replicas representing everyday activities (See Figure 8). One of these replicas, which today is found at the Metropolitan Museum of Art, depicts a granary with scribes writing on boards and papyrus while workers measure the entry and exit of grain as it is accumulated in storage bins. The scribes recorded all transfers of grain and calculated available supplies for the making of bread and beer.[5] In this replica it is possible to see, in a single glance, the operation of some of the necessary components for the functioning of large administrative and political organizations: writing, arithmetic, and standard weights and measures, all in the hands of a group of experts who work in the service of a ruler to guarantee the efficient management of the collective means of survival.

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[4] Meketre was a chancellor during the reign of Mentuhotep II in ancient Egypt, twentieth century B.C.

[5] Metropolitan Museum of Art, "Tomb of Meketre: Granary," accessed October 11, 2006, http://www.metmuseum.org/explore/newegypt/htm/wk_gran.htm.

Figure 8. Granary, Meketre Tomb

Granary. Thebes, tomb of Meketre, early Dynasty 12, ca. 1985 B.C.

As happens with other intellectual technologies, the development of systems of measurement has been intertwined with the flourishing of political and administrative institutions. Not accidently, archeologist Gordon Childe locates the origin of complex weights and measures as part of "the revolution in human knowledge," when ancient Sumerians, Egyptians, and Indians formulated new methods of transmitting experience and organizing knowledge—"the beginning of writing and of mathematics and the standardization of weights and measures coincide in time with [this] revolution."[6] The

[6] Gordon Childe, *Man Makes Himself* (Wiltshire: Moonraker, 1981), 153-154; see also his *What Happened in History* (Baltimore: Penguin, 1961), 107-108. Other relevant works on measurement and archeology: A. E. Berriman, *Historical Metrology: A New Analysis of the Archaeological and the Historical Evidence*

administration of revenue by public servants, among other key state functions, required uniform measures, a system of numeral notation, and rules of counting.

Units of measurement had existed prior to this "knowledge revolution," but those units were usually based on bodily limbs and individual objects, which made them rather "personal" standards. These measures proved ineffective for collective labor that demanded accuracy and cooperation among several workers. Standardization was needed. Fixed values were given to units like the *finger* and the *cubit*, and social standards were materialized on measuring rods and stone weights—in other words, they were made conventional. Like language and writing, standard measures rely on convention and social usage. Measuring by conventional standards, Childe observed, "is more abstract than the comparison of concrete individual objects. And all measurement involves abstract thinking. In measuring lengths of stuff you ignore their materials, colors, patterns, textures, and so on, to concentrate on length. Ultimately this leads to concepts of 'pure quantity' and 'Euclidean space.' "[7]

As a general tendency, cohesive political units tend to have—with greater or lesser consistency—unified metrological system. And as early centralized states began to conquer and absorb smaller social organizations, they forced their own units of measurement onto their newly acquired territories. Fittingly, Arnold Toynbee included weights and measures, money, and calendars in a list of "imperial institutions," like

Relating to Weights and Measures (New York: Greenwood Press, 1953); H. J. Griffin and Erwin Reifler, *A Comparative History of Metrology* (London: Mansell, 1984); *The Archaeology of Measurement,* ed. Iain Morley and Colin Renfrew (New York: Cambridge University Press, 2010).

[7] Childe, *Man Makes Himself*, 154.

official languages and scripts, law, standing armies, and civil services. As he pointed out in *A Study of History,*

> Standard measures of time, distance, length, volume, weight, and value are necessities of social life at any level above the primitive. Social currencies of these kinds are older than governments; they became matters of concern to governments as soon as these latter come into existence. […] The negative *raison d'être* of governments is to ensure at least a modicum of social justice between their subjects, and, in most private issues of a "business" kind, standard measures of some sort are involved. Standard measures thus concern governments of all kinds, but they are of particular concern to universal states; for these, by their nature, are confronted with the problem of holding together a far greater diversity of subjects than are usually found under the rule of a parochial state, and they have a special interest in the social uniformity that standard measures promote, if these are effectively enforced.[8]

It is not surprising then that many of the measures used in Europe had Roman names, or that some of the most successful cases of political centralization in the history of Europe—such as the Charlemagne's reign—were also important periods for the standardization of measures.

As Witold Kula noted, "the right to determine measures is an attribute of authority."[9] Rulers are the ones who make measures mandatory, keep the custody of standards, unify measures in a territory, and punish metrological transgressions. Also,

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[8] Arnold Toynbee, *A Study of History: Abridgement of Volumes VII-X* (New York: Oxford University Press, 1987), 54-55.

[9] Witold Kula, *Men and Measures* (Princeton: Princeton University Press, 1986), 18. As William Hallock and Herbert Treadwell Wade, observed, "As the fixing of weights and measures is manifestly an attribute of government, so any successful reforms must depend upon the character and strength of a particular government, and in order to influence neighboring countries the territory affected should be comparatively large and the number of its inhabitants considerable" (*Outlines of the Evolution of Weights and Measures,* 81).

"the frequent struggles centered about metrological competence of the constituted power are but a manifestation of the rivalry between various organs of authority aspiring to control measures in order to bolster their standing."[10] In some social orders, competing institutions may use different systems of weights and measures as a means of asserting authority within a particular sphere; in medieval European villages, for instance, one measure was used in the market, another for Church tithes, and another one to pay dues to the manor. *Fragmented political structures inhibit the establishment of unified and uniform systems of measurement*. As the theorist of sovereignty, Jean Bodin, noted in 1576:

> If coinage is one of the rights of sovereignty, so too is the regulation of weights and measures, even though there is no lord so petty that he cannot pretend to this prerogative by the authority of local custom, to the great detriment of the commonwealth. This is why King Philip the Fair, Philip the Tall, and Louis XI resolved that there would be only one system of weights and measures, and to this end all the feudal measures were equalized throughout most of the kingdom […]. But implementation proved more difficult than anticipated on account of the disputes and lawsuits that resulted from it.[11]

Absolute monarchs and modern states, in their quest for centralization, sought to gain "monopoly of metrological jurisdiction as one of the fundamental attributes of sovereign power"[12]—not accidentally constitutions of modern states give the competence of weights and measures to the central authority. In this regard, in spite of its

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[10] Kula, *Men and Measures*, 18-19.

[11] Jean Bodin, *On Sovereignty* (New York: Cambridge University Press, 1992), 80-81.

[12] Kula, *Men and Measures*, 23.

revolutionary upbringing and republican imprint, the metric system was quickly recognized by returning monarchies in Europe, after Napoleon's downfall, as an invaluable *administrative tool* that would be useful to increase their own power—Louis XVIII, in France, and William I, King of the Netherlands, for instance, decided to maintain it.

Moreover, metrological autonomy is a *symbol of sovereignty*. In the Middle Ages, for example, when cities gained self-determination in metrological matters, they carefully protected that privilege to show their freedom and autonomy; but when a city was conquered, frequently they were forced to use the conqueror's measures. This bond between measurement and sovereignty is suggested by the double meaning of the English word *ruler,* which means both "the person who rules and commands," and "measuring stick."[13] Symbolic representations of this link between sovereignty and measurement can be tracked down to the twentieth century BC in the Near East, where archeologists have found statues depicting governors with a graduated rule in his hands or on his lap[14] (a visual representation of power that was widely used in other contexts as well). See Figures 9 and 10.

[13] The *Oxford English Dictionary* actually reports that both meanings date from the fourteenth century.

[14] Berriman, *Historical Metrology*, 4.

Figure 9. Statue of Gudea

Statue of Gudea, Ruler of Lagash, bearing on his knees a graduated rule. Mesopotamia. Third milleminium B.C.

Figure 10. Henery, the first King of England

"Henery, the first King of England," holding a standard measure of length in his right hand. In the inscription: "weights and measures I corrected true."

State and Monopoly Mechanisms

According to the now classic definition coined by Max Weber, the state "is a human community that successfully claims the *monopoly of the legitimate use of physical force* within a given territory."[15] Taking Weber's formulation as starting point,

[15] Max Weber, "Politics as a Vocation," in *For Max Weber: Essays in Sociology* (New York: Oxford University Press, 1958), 78.

subsequent theorists have extended his notion on state, monopoly, and power. Norbert Elias, for example, emphasized that equally essential for the states as part of their exclusive right to raise armies is their ability to monopolize taxation—and he developed this idea on what he called the "monopoly mechanism."[16] Along the same line, Pierre Bourdieu argued that there is a "circular causality" with the development of armed forces and the collecting of tributes and taxes.[17] Raising armies asks for the exaction of economic resources to pay soldiers and finance campaigns; at the same time, the control on the means of violence makes the levying of taxes feasible.

Along with these basic forms of monopoly, modern states have also tried to secure sole control of other activities, like the monopoly of regulating the monetary system and the creation and coining of money[18] (jurisdiction over these economic instruments and the establishment of an efficient fiscal system has had further repercussions, like aiding the creation of national markets).[19] And this list of state monopolies can be expanded further; for example, John C. Torpey has drawn attention to how modern states and the international state system have expropriated the legitimate means of movement (mainly the movement across international boundaries) by depriving people of the freedom to move across certain spaces and to make them dependent on states for authorization to do so—an authority that was not that long ago in private

[16] Norbert Elias, *The Civilizing Process* (Oxfrod: Blackwell, 2000), 268-277; Stephen Mennell, *The American Civilizing Process* (London: Cambridge, 2007), 11-17.

[17] Pierre Bourdieu, "Rethinking the State: Genesis and Structure of the Bureaucratic Field," in *State/Culture,* ed. George Steinmetz (Ithaca: Cornell University Press, 1999), 59.

[18] Max Weber, *Economy and Society* (Berkeley: University of California Press, 1978), 166.

[19] Bourdieu, "Rethinking the State," 59.

hands.[20] And Elias again highlighted how the setting of time also became one of the monopolies of states[21]—a crucial attribute that helps greatly to control the rhythms of social activity.

Here I want to shed light on the overlooked fact that as part of this very same dynamic of concentration of power, *modern nation-states have monopolized the legitimate means of measurement*.

Monopolization of the Legitimate Means of Measurement

The authority to define units of measurement, store physical standards, prescribe proper methods of measurement, appoint inspectors, and carry out punishments for metrological offences, which was theretofore held in the hands of various, uncoordinated authorities—cities, corporations, guilds, town markets, etcetera—was expropriated by state authorities during the nineteenth and twentieth centuries. In the same way that states dispossess their domestic competitors of the instruments of physical violence and the right to use them, so they warrant their monopoly on the legitimate means of measurement by dispossessing social groups of their measuring rights and authority. Briefly, this process can be described as the transition from *multiple metrological sovereignty* to a single sovereignty that holds the *monopoly of the legitimate means of measurement*. Usually, multiplicity of system measures in a single territory reflects a

[20] John C. Torpey, *The Invention of the Passport: Surveillance, Citizenship, and the State* (New York: Cambridge University Press, 2000), 4-5.

[21] Norbert Elias, *Time: An Essay* (Oxford: Blackwell, 1992), 53.

multiplicity of sovereignties. That is why it is not an accident (as we saw in the previous chapter) that the adoption of the metric system is, most of the times, preceded by a massive social change—a change frequently characterized by the destruction of old institutions and the start of a new central sovereignty.

This does not mean necessarily that states control measures effectively, only that they monopolize the authority to sanction measuring practices. Neither does this means, of course, that all states have followed the same monopolization trajectory nor that they have been equally effective in their aim to make this monopoly effective—as I will show in this chapter, with the cases of Mexico and the United States.

The rights that are included in the monopoly over the legitimate means of measurement include, among others, the right to:

- Determine the legal units of measurement—and the subsequent banning of all other units—making those units the only acceptable in civil contracts and commercial exchanges.
- Retain the physical standards in which the official units of measurement are embodied.
- Implement a traceability chain to secure the faithfulness of all standards and instruments.
- Determine *how* objects should be measured (this includes the techniques and procedures of verification and calibration; and the proper way to weight and gauge commodities in the market place).
- Resolve how frequently standards should be verified and who can verify them.
- Designate inspectors to validate proper employment of weights and measures.
- Set fines and penalties for metrological wrongdoings.

- Specify when and how the official measurement system should be taught in schools (which in some cases include the right to make metrological education mandatory and even to select the teaching materials to be used in classrooms).

As I already mentioned, establishing a monopoly on the legitimate means of measurement serves many purposes for a state, such as undermining local powers (political and economic); making the territory legible and homogeneous; consolidating an internal market; enhancing tax exaction and state revenue; reducing commercial frauds, which aids the administration of justice; establishing proper conditions for international trade; and helping to enhance nationalistic feelings and experiences.

One of the problems of the *political life of measures* in Europe and the Americas until the beginning of the nineteenth century (in some cases decades later), was *multiple metrological sovereignty*—i.e. the lack of a single unified political hierarchy to regulate weights and measures in a given territory and the presence of competing claims by two or more opposing parties over metrological authority of a defined geographical region (town, city, or province) or activity (business or profession). There usually was a proclaimed—and nominally recognized—sovereign metrological authority, but in practice that authority was ignored or challenged. This situation ended in France, for example, on August 4, 1789 with the abolition of feudal privileges that deprived lords from the right to have final say in metrological matters in their own estates. The revolution unified all of the French under a sole authority that set a single system and settled all disputes—of course it is not a coincidence that the birth of the metric system and the establishment of this sovereign and autonomous metrological power occurred simultaneously. In the nineteenth and twentieth centuries, when other nation-states have looked for the proper instruments to secure this monopoly, the metric became a ready-made system, legitimized by its scientific aura, and with a proven record of success.[22]

Measurement, Knowledge, Legibility

As Georges Gurvitch indicated, states are—among other things—social frameworks of knowledge. The cognitive systems of the state accord primordial importance to what Gurvitch calls "perceptual knowledge of the external world."[23] Modern states perceive the world from the point of view of assuring the regularity of its functioning and identifying economic resources in the territory in which they struggle. For this purpose, states resort to the quantification of time and space and establish standards of measurement, which result in spatio-temporal references. States emphasize rational and technical types of knowledge to manipulate productive forces and control populations.[24] To this we can add the creation and implementation of reliable and uniform systems of weights and measures, which is one of the key cognitive strategies employed by the administrative apparatus to delineate the world.

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[22] Edward Cox, "The Metric System: A Quarter-Century of Acceptance (1851-1876)," *Isis* 13 (1958): 77.

[23] Georges Gurvitch, *The Social Frameworks of Knowledge* (New York: Harper, 1972), 74. Also relevant for the relation between state and knowledge is Norbert Elias, "Knowledge and Power," in *Knowledge and Society*, ed. N. Stehr and V. Meja (New Brunswick: Transaction Books, 1984), 251-291.

[24] Gurvitch, *The Social Frameworks of Knowledge*, 73-78.

Exploring an idea similar to that of Gurvitch, Bourdieu has emphasized how states monopolize the legitimate use of both physical violence and *symbolic* violence; the state exerts the latter in the form of mental structures and categories of perception and thought. The state is the culmination of the concentration of various forms of capital: capital of the physical instruments of coercion, economic capital, symbolic capital, and, of particular importance for our purpose, *informational capital*.[25] In Bourdieu words,

> The state concentrates, treats, and redistributes information and, most of all, effects a *theoretical unification*. Taking the vantage point of the Whole, of society in its totality, the state claims responsibility for all operations of *totalization* […] and of *objectification,* through cartography (the unitary representation of space from above) or more simply through writing as an instrument of accumulation of knowledge, as well as for all operations of *codification* as cognitive unification implying centralization and monopolization in the hands of clerks and men of letters.[26]

Bourdieu goes on to say that the state shapes mental structures and imposes shared forms of thinking, cognitive structures, categories of perception, and principles of vision and division that social agents apply to all things of the world.[27] The state has therefore the ability to inculcate within a given territory a *nomos,* and become the foundation of a "logic conformism," a tacit agreement over the meaning of the world. This is achieved especially through schooling and the generalization of elementary education.

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[25] Bourdieu, "Rethinking the State," 56-57.

[26] Bourdieu, "Rethinking the State," 61.

[27] Bourdieu, "Rethinking the State," 67.

It is debatable how much the Bourdieuian account of the cognitive penetration of the state is on target for every single empirical case—as it is easy to see how his description would fit better in France than in England, for example. But Bourdieu's framework can help to place the state's efforts to establish a homogenous system of measurement in a broader context. Systems of measurement are, in the end, languages that shape the perceptual and cognitive structures of people; securing the existence of a sole system of measures also secures a way of perceiving and classifying the world.

On the other hand, it should be said that it is not a coincidence that in many cases state efforts to homogenize weights and measures coincide with the rise of censuses and maps—as famously described by Benedict Anderson.[28] For Anderson, these instruments serve as a means for states to think of their domains in a "totalizing classificatory grid" that can be applied to peoples, regions, religions, languages, and products under their control. For the colonial state, this was manifest in an ambition for "total surveyability," as the colonial state "did not merely aspire to create, under its control, a human landscape of perfect visibility; the condition of this 'visibility' was that everyone, everything, had (as it were) a serial number. This style of imagining did not come out of thin air. It was the product of the technologies of navigation, astronomy, horology, *surveying*, photography and print."[29]

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[28] Benedict Anderson, *Imagined Communities* (Verso: London, 1991), 163-185.

[29] Anderson, *Imagined Communities,* 184-185. Emphasis added.

Following a similar line of thought, James Scott has shown how metrological standardization of weights and measures is a "tool of legibility" for modern states.[30] The fragmented nature of customary weights and measures, Scott underlines, creates administrative incoherencies that work to the advantage of local power-holders; centralized states strive to introduce uniform measures that make territories, resources, and population more easily intelligible for administrators. These opposing interests promote a clash between "local knowledge and practices on the one hand and state administrative routines on the other."[31] Since traditional measures are local, contextual, and historically specific (as they are the product of indigenous understandings of labor and environment), centralized states cannot create coherent representations of their whole territories based on such standards. Local measures "would not lend themselves to aggregation into a single statistical series that would allow state officials to make meaningful comparisons."[32]

The illegibility of local practices of measurement, Scott continues, not only creates administrative mayhem and gross inefficiencies, but also compromises crucial elements of state security. For example, *food supply* could be in jeopardy without comparable units of measure as a result of the complications in monitoring markets and

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[30] James C. Scott, *Seeing Like a State* (New Haven: Yale University Press, 1998), 24-33.

[31] Scott, *Seeing Like a State*, 24. As Porter also stresses, the problem in metrological matters of "separating knowledge from its local context" is shared by the political, economic, and scientific spheres, (*Trust in Numbers*, 22).

[32] Scott, *Seeing Like a State*, 27. This also matter for "administrative power" of the state based on the storage of information," see Anthony Giddens, *The Nation-State and Violence* (Berkeley: University of California Press, 1987), 172-181.

contrasting regional prices for basic commodities; unstandardized measures also thwart *taxation,* because the state could not obtain equivalent information about harvests and prices. "No effective central monitoring or controlled comparisons were possible without standard, fixed units of measurement."[33] For all this, the metric system—as the most widely recognized standardized, fixed system of measurement available—became very quickly the perfect intellectual instrument for governments to crack down on local metrological dialects and launch an intelligible, homogenous, and universal language able to render territories, populations, and resources legible.

In summary, the state monopoly of the means of measurement, from a cognitive point of view, involves two distinctive facets: first, the gathering and management of information; second, the imposition of a "logic conformism" in society at large. To this we need to add a third one: the production and distribution of knowledge. The implementation of the metric system—or any other exclusive system of measurement—in a country is a work of distribution of knowledge (as present and future users of the new system need to learn it); and it also requires the production of knowledge (i.e. state-sponsored knowledge): manuals (both for bureaucrats and for lay persons), reports, translations of metric and customary units, catalogs of local measures, tables of conversion, and so forth. Weights and measures are intellectual tools; but to control them they have to become an object of interrogation themselves; metrology is, above all, a science of the state.

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[33] Scott, *Seeing Like a State*, 30.

Taxation and Measurement

The need for improved fiscal conditions and more fluid trade in increasingly integrated national markets has prompted states to seek more stable systems of measurement. In the same way that unstandardized measures greatly complicate the state's administrative apparatus for inspecting its territory, so they set hurdles for the collection of state revenue. A poorly standardized territory means that a uniform system of taxation has to account for foreign and domestic customary variations in weights, measures, and containers.[34] To improve their revenue procedures, states have worked methodically to reduce the complexity and diversity of metrological standards and practices, with especial emphasis on the standards and containers used for excised goods.

That is why throughout the nineteenth and twentieth centuries governments usually coupled their plans for metrological reforms with their strategies for taxation proficiency. Policies against metrological diversity were usually devised by and for the internal revenue offices. This, on the other hand, generated some interesting paradoxes, as William Ashworth points out, "To appear fare, taxation should be universally applied and governed by a set of standards equitably applied. However, the imposition of such measures required illiberal methods that often rode roughshod through widespread diversity."[35] But crushing local units of measurement has had some extra economic

[34] William J. Ashworth, "Metrology and the State: Science, Revenue, and Commerce," *Science* 19 (2004): 1314.

[35] Ashworth, "Metrology and the State," 1315.

benefits for central states; unifying the territory under a single metrological system helps to connect more effectively geographically remote areas with the more economically active regions. National unification of weights and measures brings "areas together through metrology."[36]

It is not an accident then that the first federal legislation in the United States regarding weights and measures was intended to aid the work of custom houses, nor that the Mexican state showed interest on the metric system for the first time in their attempt to improve taxation on the import and export of commodities in commercial ports.

Currencies, Measures, Nationhood

The creation of national currencies and the establishment of standardized weights and measures are complementary processes that run simultaneously. They are usually driven by the same necessities, maintained by the same institutions, and, in many cases, have produced similar social effects. A single national currency and a single system of measurement are both institutional answers to the needs brought by the unification of national markets and the growth of centralized governments. It was the state monopoly to coin money and the state monopoly on the means of measurement that made joint monetary and metrological unifications possible. And these processes of homogenization have helped to enhance national identities as well as to boost state capabilities.

[36] Ashworth, "Metrology and the State," 1316.

Eric Helleiner has shown how during the nineteenth century, nation builders saw territorial currency as an important instrument to promote national identity—a parallel, for example, to the creation of standardized national languages.[37] For Helleiner, national currencies have the potential to be a unifying medium of communication. This function can be better appreciated by comparing the present monetary situation in the majority of the countries with their monetary situation two hundred years ago, when two distinct problems impeded smooth communication in the marketplace. First and most obvious, there was a dislocation between cities, regions, and provinces. The value of coins and metals used to vary from one location to the next; besides, several economic entities coined their own money that circulated locally. Second, there was a marked dissociation between the money employed by the upper and lower economic classes. Gold and silver were almost exclusively used by the "most affluent," while the poor used copper coins and low-denomination tokens. The interchangeability between these sets of monies was not transparent. The establishment of national currencies, the manufacturing of large amounts of small change (that replaced privately issued tokens), and the banning of private, local, and foreign currencies helped to unify countries across geographic and class lines[38]—a product of states exercising their monopoly over the production and regulation of money.

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[37] Eric Helleiner, "National Currencies and National Identities," *American Behavioral Scientist* 41 (1998): 1414.

[38] Helleiner, "National Currencies," 1414-15. This process ran in many cases parallel to banning the circulation of coins and bills made in foreign countries.

Helleiner references Simmel's depiction of money as having a "qualitatively communistic character," derived from its ability to be a denominator for all values. Money reduces everything in the nation to a common pecuniary language, and by making all distinctions disappear, the national community could be imagined as leveled on "a kind of horizontal comradeship." But with national currencies, the leveling function of money stops at the border, beyond which other currencies operate. "In this way," Helleiner concludes, "the 'leveling' and 'communistic' characteristic of national currencies may have contributed not only to a sense of national affiliation but also to a feeling of distinction from others."[39]

From here it is easy to see how the establishment of homogenous systems of measurement shares the same leveling, communistic, and unifying properties as the establishment of national currencies. When all social classes and all regions of a country share the same form of money and the same units of measurement, they are connected by common and homogeneous mediums of communication.

Needless to say, the link between these processes has marked limitations. For one thing, one of the main nationalistic properties of money, the massive reproduction of a "national imagery" engraved in coins and printed on bills, is impossible to replicate in weights and measures. Also, national currencies underline differences between nations; but the universalistic character of the metric system does not allow that in the metrological realm—as one of the pillars of metrication is that there ought to be no

[39] Helleiner, "National Currencies," 1418.

distinction between one's own measurement system and those used in other countries. Nevertheless, it is interesting to notice how in countries like England, nationalistic sentiments have nourished the opposition to both the euro and the metric system—a case that may help to confirm that national identity is entangled with money and measures.[40]

We will see how in Mexico the metric system was perceived, especially in the 1930s, as an instrument to unify the country, to eliminate local particularities, and to create a homogeneous national population. National metrication was conceived as a mechanism to homogenize practices, to create a single national space with no local differences or idiosyncrasies—in other words, to *erase history*. On the other hand, in the United States (as in England and other places) nationalist sentiments were strongly attached to customary measures, and for some social groups, the metric system was seen as a menace to American traditions and values, a sentiment that galvanized the opposition and created a strong obstacle for metrication.

Finally, before we jump into the Mexican and American cases, a caveat is necessary. It should be understood that all these theories stress what the states *aspire* to do; not necessarily what they actually do regarding the administration of metrological matters. States may want to compel or force the people living in their territories to use a uniform system of measurement, but that desire does not always translate into reality. Not all states are equally effective, patient, perseverant, and resourceful enough to mold the mores of millions of individuals.

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[40] See for example Nico Hines, "EU Ends 'Pointless Battle' to Make UK Metric," *The Times,* September 11, 2007; Ian Traynor, "EU Provides Reprieve for Mile and Pint," *The Guardian*, September 12, 2007.

2. STATE AND METRICATION IN MEXICO[41]

The process of metrication in Mexico, from the standpoint of the state, passed through three recognizable stages, each with distinctive characteristics in terms of what kind of political and administrate apparatus was under construction and with particular views on what meaning and function the metric system ought to fulfill at that moment. First, from 1857 to 1867, the period of initial adoption (purely nominal) of the metric system, when the erection of a liberal state—centered around a new Constitution—was underway in the midst of civil war. Second, from 1895 to 1905, when the actual introduction of the metric system started as part of a process of state strengthening, economic growth, and increasing international integration. Lastly, from 1928 to 1940, during the consolidation of a post-revolutionary and nationalistic state, when the final large-scale metrication campaign took place in the country.

Before we analyze these three phases a word is necessary about the institutional setting that the country inherited from the colonial regime.

Colonial Legacy

Before the metric system was implanted in Mexico, people had used hundreds of measures that came from Medieval Europe, the Islamic culture, and pre-Columbian

[41] This section draws from *A peso el kilo* (Mexico: Libros del Escarabajo, 2007).

civilizations.[42] These measures coexisted from the sixteenth to the nineteenth centuries in a metrological mixture formed in the three centuries of Spanish colonial rule, and started quickly after the Conquest.[43]

Briefly after defeating the Aztecs in 1521, *conquistador* Hernán Cortés dictated an ordinance to regulate weights and measures, ordering that in all townships there should be an observer of weights and measures (called *fiel*) who should visit all

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[42] On pre-Columbian measures: Barbara Williams and María del Carmen Jorge, "Surface Area Computation in Ancient Mexico: Documentary Evidence of Acolhua-Aztec Proto-Geometry," *Symmetry: Culture and Science* 12 (2001): 185-200; Barbara Williams and María del Carmen Jorge, "Aztec Arithmetic Revisited: Land-Area Algorithms and Acolhua Congruence Arithmetic." *Science* 320 (2008): 72-77; Víctor Castillo Ferreras, "Unidades nahuas de medida," *Estudios de Cultura Náhuatl* 10 (1972): 195-223; Marcos Matías Alfonso, *Medidas indígenas de longitud en documentos de la ciudad de México del siglo XVI* (Mexico: CIESAS, 1984); Francisco Guerra, "Weights and Measures in Pre-Columbian America," *Journal of the History of Medicine and Allied Sciences* 15 (1960): 342-344; Franz Tichy, "Una contribución al problema de la medición de longitud en la arquitectura del México precolombino," *Revista Mexicana de Sociología* 51 (1989): 335-348; Patricia J. O'Brien and Hanne Christiansen, "An Ancient Maya Measurement System," *American Antiquity* 51 (1986): 136-151; Saburo Sugiyama, "Teotihuacan City Layout as a Cosmogram: Preliminary Results of the 2007 Measurement Unit Study," in *The Archaeology of Measurement*, ed. I. Morley and C. Renfrew (New York: Cambridge University Press, 2010), 130-149; John E. Clark, "Aztec Dimensions of Holiness," in *The Archaeology of Measurement*, ed. I. Morley and C. Renfrew (New York: Cambridge University Press, 2010), 150-169.

[43] On colonial measures: Manuel Carrera Stampa, "The Evolution of Weights and Measures in New Spain," *The Hispanic American Historical Review* 29 (1949): 2-23; Virginia García Acosta, "Weights and Prices of Bread in Eighteenth-Century Mexico," *Cahiers de Métrologie* 11-12 (1993-1994): 45-57; Serge Gruzinski, "Mesures espanognoles et mesures indiennes dans le Mexique du XVI siècle," in *La juste mesure: quantifier, évaluer, mesurer entre orient et occident, VIIIe-XVIIIe siècle,* ed. Laurence Moulinier, *et al.* (Saint-Denis: Presses Universitaires de Vincennes, 2005), 145-157; Jacinta Palerm and Carlos Chairez, "Medidas antiguas de agua," *Relaciones: Estudios de Historia y Sociedad* 23 (2002): 227-251; Teresa Rojas Rabiela and Ismael Maldonado, "La Geometría práctica y mecánica de Joseph Saénz de Escobar (*ca.* 1706). El capítulo XVI." *Boletín del Archivo General Agrario* 13 (2001): 37-48; Cecilio Robelo, *Diccionario de pesas y medidas mexicanas antiguas y modernas* (Cuernavaca: Imprenta Cuaunahuac, 1908); Iris Santacruz and Luis Jiménez, "Pesas y medidas," in *Siete ensayos sobre la hacienda mexicana, 1780-1880,* ed. Enrique Semo (Mexico: INAH, 1977), 247-269; Luis Weckmann, *La herencia medieval de México* (Mexico: El Colegio de México, 1983); Alberto J. Torres, *Pesos y medidas antiguas en México* (Guadalajara: Gobierno del Estado de Jalisco, 1987). Herbert J. Nickel, *Agrimensura y cartografía en México, 1720-1920* (Mexico: UNAM-El Colegio de Mexico, 2010), CD-Rom. For a brief overview of history of measures in the country, Jean-Claude Hocquet, "Weights and Measures in Mexico," in *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures,* ed. Helaine Selin (Dordrecht: Kluwer Academic Publishers, 1997), 1023-1025.

warehouses and stamp measuring and weighing instruments with the town's seal; vendors could not sell using any other gauging tools than the one reviewed by the observer.[44]

This and subsequent ordinances in what became the Spanish viceroyalty of New Spain show the interest of the new authorities to regulate the commerce of basic goods and the way in which they should be measured.[45] We can also see in those documents the fragmentation in the structure of those with the responsibility to regulate weights and measures: it was every single town, village, and city the one on charge to have its own standards, to test and seal them, and to police merchants with observers appointed locally. This relative metrological autonomy was one of the deepest roots of the prodigious diversity of local units of measurement during the colonial period—and afterwards.

Who were those people that brought European and Arabic measures to the New Spain? And what do they measure for?[46] Some of the names of the very measures they brought may give us a clue. For example, one of the most common units of land area used during the colony was the *caballería*, which referred a surface of 1 104 *varas* long and 552 *varas* wide. But this geometric dimension is not the essential part of its definition. More meaningful is its etymology, which comes from the word *caballero* (knight). *Caballería* was the portion of land that a knight who contributed to a conquest received after a new territory was obtained. As the *caballería*, other measures (like

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[44] Hernán Cortés, *Cartas y documentos* (Mexico: Porrúa, 1963), 342.

[45] A compilation of these ordinances, see Mariano Galván Rivera, *Ordenanzas de tierras y aguas* (Mexico: Librería del Portal de Mercaderes, 1849).

[46] Jean-Claude Hocquet, "Pesos y medidas y la historia de los precios en México: algunas consideraciones metodológicas," in *Los precios de alimentos y manufacturas novohispanos,* ed. Virginia García Acosta (Mexico: CIESAS, 1995), 72-85.

peonía) bear the imprint of plunder. Other important measures were introduced to calculate the taxes paid by natives to the Europeans (like the *fanega*).[47]

Colonial ordinances regarding weights and measures, some dictated by the crown in Spain, others by New Spain's viceroys, aimed to set permissible units of measurement for commerce, to place standards in public places, and determine fines and penalties to offenders (penalties that range from confiscation of scales and pecuniary fines, to whipping and exile).[48]

The observers (*fieles*) were one of the key participants in New Spain's metrological structure. They were on charge to guarantee the proper functioning of markets, customs, and public granaries. There were several different types of observers. The *fiel almotacén* was in charge to watch weights and measures in the cities. The *fiel de romana* was the official who oversaw the weighing of meat in slaughterhouses. The *fiel medidor* examined the measurement of taxable grains and liquids, like oil and wine. The *fiel marcador* was in charge of checking the weight and assay the value of coins and metals. And the *fiel ejecutor* asisted in the verification (or second weighing) of food stuff in the markets, looking to prevent frauds and short measures in the quality and quantity of

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[47] See Charles Gibson, *The Aztecs under Spanish Rule* (Stanford: Stanford University Press, 1964), 261; James Lockhart, *The Nahuas after the Conquest* (Stanford: Stanford University Press, 1992), 144-146, 166-167; Serge Gruzinski, "Mesures espanognoles et mesures indiennes dans le Mexique du XVI siècle," in *La juste mesure: quantifier, évaluer, mesurer entre orient et occident, VIIIe-XVIIIe siècle,* ed. Laurence Moulinier, *et al.* (Saint-Denis: Presses Universitaires de Vincennes, 2005), 145-157.

[48] Manuel Orozco y Berra, "Medidas y pesos en la república mexicana," in *Diccionario universal de historia y de geografía* (Mexico: Imprenta de F. Escalante y Compañía, 1854), V: 207.

the products.[49] These were jobs with plenty of complications, but also filled with opportunities to make extra money on the side by corruption and bribery (as can be seen in the numerous complaints made by merchants and Indians, for example).[50]

These *fieles* were among those positions that the Spanish crown put for sale. Like court scribes, mint assayers and coiners, town constables, and many others, the ranks of *fiel* were openly sold to any "qualified person." The post was only granted after the king sanctioned it. Other inspectors of weights and measures were appointed by every guild, as it was indicated in their ordinances. Silk-mercers, coopers, butchers, barkers, and others selected their own *fieles* and *veedores* (observers) to keep an eye on the measuring instruments relative to their respective trade and to secure that they were tested and marked with the city seal.[51] By subjecting the members of the guilds to use measures verified with the town standards, the city council tried to control the corporations and the selling of products in general.[52]

Overall, what this institutional structure produced was a system of measurement poorly standardized, with numerous measures used only at a local level, and differentiated according to occupational groups. Every city, every guild, and in some cases every market had its own standards and its own inspectors of weights and measures. Besides that, different sets of measures were utilized for different products or

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[49] Joaquín Escriche, *Diccionario razonado de legislación y jurisprudencia* (Madrid: Imprenta de Eduardo Cuesta, 1874), 1058-1059.

[50] See AGN, Indios, vol. 10. exp. 175, and vol. 56, exp. 18.

[51] *El trabajo en México durante la época colonial,* ed. Francisco del Barrio Lorenzot (Mexico: Secretaría de Gobernación, 1920).

[52] Manuel Carrera Stampa, *Los gremios mexicanos* (Mexico: Ediapsa, 1954), 181.

commodities. This variety of measures complicated large-scale commerce, science, and taxation, not only in the New Spain, but also during the first decades of independent life in Mexico.

Measures in Independent Mexico

On September 27, 1821, the Mexican Empire declared its independence from Spain. The short lived Empire was replaced by the First Republic, that in its Constitution 1824 gave Congress faculties to "determine and standardize the weight, value, and denomination of money in all the States of the Federation, and to adopt a general system of weights and measures."[53] Every little was done, however, during the first decades of independent life, regarding weights and measures. Deficient political organization, immense internal conflicts, and foreign invasions marked this period. Among the few things worth mentioning is the printing in 1825 of the first publication with equivalences between metric and Mexican customary measures.[54] And in 1840-1841 some designs were advanced for a decimal currency.[55]

Things started to pick up some steam in 1849, when a commission in Congress was formed to study the possibility of adopting the "French metric system," as it was

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[53] *Constitución Federal de los Estados Unidos Mexicanos*, article 50.

[54] *Guía para el conocimiento de monedas y medidas de los principales mercados de Europa, en las operaciones del comercio. Con una noticia de las dimensiones de las medidas de los áridos y agrarias que se usan en los Estados Unidos Mexicanos* (Mexico: Oficina de Ontiveros, 1825).

[55] Miguel L. Muñoz, "The Decimal Monetary System, Its Adoption in Mexico," in *Antología Numismática Mexicana,* (Mexico: M. L. Muñoz, 1977), 281; Theodore Buttrey, *Guía de las monedas decimales mexicanas, 1863-1963* (Racine, Wisconsin: Casa Editora Whitman, 1963), 16.

called. Some projects of law to go metric in measures and decimal in currency were drafted—one of them by Senator Merlcho Ocampo.[56] Ocampo, one of the most visible figures in Mexican liberalism, was a self-taught scientist who lived for some months in France (where he studied surveying and other disciplines) in 1840, exactly the year when the mandatory use of the metric system was resumed in that country after an impasse of more than two decades. The project was discussed, but no action was ultimately taken by Congress.[57] Some of the debates that surrounded this law are illustrative of how the whole question of regulating weights and measures has been seeing in the country.

The most visible participant in the newspapers debate around the 1849 law was Lucas Alamán, one of the most influent politicians during the first half of the nineteenth century in Mexico, and a brilliant and versatile intellectual—a polymath (mainly known for his work as historian and founder of the National Archive and the Museum on Natural History, but also an engineer trained in the School of Mines who cultivated mineralogy, botany, and chemistry) who has drawn comparisons with Thomas Jefferson and Alexander Hamilton.[58] He was co-founder of the Mexican Conservative Party, and from 1823 to 1853 he served three times as minister of foreign relations. He and his liberal adversary Ocampo had a very hostile attitude towards each other.

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[56] Melchor Ocampo, *Obras Completas de Melchor Ocampo* (Morelia: Comité Editorial del Gobierno de Michoacán, 1985), I: 264-268; José Valadés, *Don Melchor Ocampo: reformador de México* (Mexico: Patria, 1954), 191-192.

[57] The project of law that was actually presented and debated can be seen in *El Siglo Diez y Nueve,* Febrarury 22, 1849; on some of the polemics surrounding it, see *El Siglo Diez y Nueve,* April 22, 1849.

[58] Eric van Young, " 'Life History and the Historical Moment': Lucas Alamán as an Economic Actor" (paper presented at Seminario Interinstitucional de Historia Económica, Colegio de México, Mexico, January 18, 2010).

In 1849, towards the end of his life, Alamán animated one of the first metric debates in the country.[59] Alamán penned a highly original article opposing metrication in Mexico—using mainly sociological, rather than technical arguments. In that article Alamán elaborated a justification for having a strong central authority handling metrological matters (something hardly surprising from a man known for consistently defending the centralist government). He defended this position by saying that "if in Mexico we would have, as was the case in France, diversity of currency, weights, and measures in every province, my opinion would be that they should be uniformed, as it is beyond doubt that legislation, the fiscal system, and everything else relative to the government of the interior should be uniform."[60] Alamán stated wrongly that there was uniformity of weights and measures in the country (such simply didn't exist, as I will show) and that a change to new system was not needed. But beyond his misleading diagnostic of Mexico's metrological situation, it should be stressed that for him it was crucial to have uniformity and central control at any cost. And more interesting is that in all the further discussions regarding metrication no one challenged this particular aspect of Alamán's argument. Many intellectuals expressed reservations about some of his observations, but nobody questioned the need for a uniform system of measurement administered by the federal government—they only quarreled about what that system

[59] Some observations on Alamán's position regarding the metric systemcan can be seen in Moisés González Navarro, *El pensamiento político de Lucas Alamán* (Mexico: El Colegio de México, 1952); and Moisés González Navarro, *Anatomía del poder en México, 1848-1853* (México: El Colegio de México, 1983), 410-411. It should be noted, however, that González Navarro wrongly stated that Alamán supported a plan for the government to adopt the metric system.

[60] Lucas Alamán, "Pesos y medidas," *El Universal*, March 22, 1849.

should be. Contrary to what happened in the United States, centralization and uniformity were undisputed guiding principles in metrological policies.[61]

The pro-metric activity resumed in 1852 when the Sociedad Mexicana de Geografía y Estadística (Mexican Society of Geography and Statistics) formed a commission to design a plan for the regulation of weights and measures. The Society had received in 1849 a fine meter standard as a gift from the French minister in Mexico. The works of the commission stalled due to an overabundance of proposals, and a second commission had to be formed in 1853, which officially recommended the adoption of the metric system.[62] But then again, no action was taken. It was only after a group of aggressive liberals deposed longtime president Antonio López de Santa Anna that the steps of passing metric legislation were finally taken.

1857: Liberal State, Metric System

On March the 15th, 1857, president Ignacio Comonfort signed a decree introducing the decimal metric system in Mexico. It said that "The French decimal metric system will be adopted in the republic, without other modifications than those demanded

[61] It should be said that despite his opposition for the adoption of the metric system as the general system of weights and measures in the country, Alamán supported that it should be learned by custom employees, and backed one of the first official studies to determine the equivalencies between metric and customary units, see *Instrucción para reducir fácilmente las pesas y medidas extranjeras designadas en el artículo 15 del Arancel de Aduanas Marítimas, decretado en 4 de octubre de 1845, a las pesas y medidas mexicanas* (Mexico: Imprenta de Torres, 1846), 3-6.

[62] Miguel Arroyo, "Segunda reseña que presenta a la Sociedad Mexicana de Geografía y Estadística, su secretario perpetuo, de los trabajos de ella desde 1852 a la fecha," *Boletín de la Sociedad Mexicana de Geografía y Estadística* 4 (1854), 340; *El Siglo Diez y Nueve,* September 8, 1854. Relevant for this context is Leticia Mayer Celis, *Entre el infierno de una realidad y el cielo de un imaginario. Estadística y comunidad científica en el México de la primera mitad del siglo XIX* (Mexico: Colegio de México, 1999).

by the nation's particular circumstances."[63] The meter, area, cubic meter, liter, and gram became the official units for length, surface, solids, liquids, and mass. At the same time, the Mexican *peseta* was established as the new monetary unit. Measures and coinage would follow decimal progressions and subdivisions.

The decree required that starting September 15 of that year the new metric measures should be employed "in all official acts and all government businesses." The same was expected from all citizens starting the first day of 1862. Those failing to comply with the new law would be "considered guilty of using false measures." Furthermore, those found in possession of standards and measuring instruments not sanctioned by the law would be penalized; and the same for those caught holding non-metric tools in stores, warehouses, offices, workshops, or laboratories. Equally, after the deadline all commercial venues should place in plain sight conversion tables that the Ministry of Development would publish for that purpose—a fine of ten Mexican pesetas was due if infringements occurred.

The same decree prohibited the manufacture of any kind of non-metric measuring tools, as well as the employment of old measures "in public acts and announcements as in private documentation, books, and commerce registers, or any other title exposed in a trial." With this legislation in place, scribes, clerks, traders, and judges, were forced to use metric units exclusively.

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[63] *Decreto de pesas y medidas de 15 de marzo de 1857* (Mexico: Fomento, 1857). To see a panoramic view of the evolution of legal dispositions in Mexico on metrological matters, see José Francisco Ramírez, "El sistema de pesas y medidas en el derecho administrativo mexicano (Law dissertation, Universidad Nacional Autónoma de México, 1969); Luis Malpica de Lamadrid, *La influencia del derecho internacional en el derecho mexicano* (Mexico: Limusa, 2002), 113-116, 164-166.

The 1857 decree also established the creation of a "scientific bureau which shall be named 'Dirección General de Pesos y Medidas' and it will be a new section in the Ministry of Development." The duties to be carried out by this weights and measures bureau listed as:

- to design and manufacture tables of comparison between the old measurement system and the new one as promote it among people;
- specify rules as of how to employ the new metric system in a proper fashion;
- sort out all the necessary expenditures to achieve the aforementioned goals;
- provide assistance for the employment of the new measures in pharmacy;
- plan and inspect the use of the new currency;
- organize verification offices (called *fielasgos* and *almotacenes*) were new measures should be validated.

This decree, overall, was an ambitious project to transform not only the weights and measures supervision in the country, but also the measuring practices of the population—a challenge that was beyond the reach of the Mexican state at that moment. But more importantly, this law laid down the legal basis to reorganize the metrological administration in the country. For the first time the whole metrological system had a sole authority, hierarchized in a clear chain of authority—with the federal government at the top. This was the blueprint to dispossess local governments and corporations from their control over weights and measures. It was a plan that needed decades to get off the ground, but once it did it proved effective.

The task that the government had ahead of it was highly problematic. There were at least four big challenges for the Mexican state:

- A large number of well-trained inspectors and local offices of weights and measures was required to enforce the new metric legislation.
- To teach the population how to use the metric system. Names and magnitudes of the metric units of measurement were completely unknown to lay people, and their decimal character was an arithmetic oddity. This required a large educational system that did not exist at the time.
- Alongside teaching the metric system, the state needed to persuade people that the new system was more useful than the old measures. A compelling propaganda campaign was needed.
- It was also necessary to either import or to build all the measuring and weighing metric instruments required by commerce and government agencies. With the new law, millions of measuring tools would become obsolete and illegal; but to replace them millions of new tools had to be provided.

These were complicated and expensive matters. There were no factories in the country to produce metric instruments; neither were technicians to calibrate the existing tools nor inspectors to verify that merchants would not take advantage of buyers who did not know how to use the new measures. The government lacked the economic, bureaucratic, and human resources to carry out such a big enterprise.

Other significant difficulty was that many of the educating and propagandistic efforts of the state were centered on printed materials, but around ninety percent of the eight million Mexicans living in the country were illiterate and the access to formal education was minimal. Besides, for those kids who actually enter into the school, the metric system was little more than a theoretical inquiry, because in the world outside the schools people did not use metric units. Teachers could lecture about meters and kilograms, but in the street merchants only employed *varas* and *arrobas*.[64] An additional problem was that the government and its scientists some times did a poor job in preparing the materials aim to help the people to learn the new system. For instance, the conversion tables with metric and customary measures—which were an indispensable tool for a successful transition—had to be made and remade on several occasions due to imprecisions and miscalculations; and once the tables and charts were finalized, the government did not print enough and it was impossible to circulate them throughout the whole territory.[65]

One of the few actions in favor of metrication that the federal government was able to put forward in a more or less consistent basis happened in 1861, when a decree ordered that the teaching of the metric system would be mandatory in elementary schools. This became a very consistent policy—sustained during the decades to come—which slowly but surely it brought some positive results.[66]

The context in which this weights and measures law was passed should not be overlooked. The fact that the law was passed just a month after the liberal Constitution

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[64] This was not something that only occurred in Mexico, it was the same, for example, in rural France, see Eugen Weber, *Peasants into Frenchmen* (Stanford, Stanford University Press, 1976), 326.

[65] On this problems and deficiencies with the convention tables, see Francisco Jiménez *et al.,* "Sistema métrico decimal; tablas que expresan la relación entre los valores de las antiguas medidas mexicanas y las del nuevo sistema legal," *Boletín de la Sociedad Mexicana de Geografía y Estadística* 10 (1863), 198-206.

[66] AGN, Pesas y medidas, box 1, exp. 1. The metric system was also part of the curricula in the curriculum reforms of 1867, 1869, 1891, and 1896, see *Memoria que el Secretario de Justicia e Instrucción Pública* (Mexico: Antigua Imprenta de J. F. Jens Sacesores, 1902).

was signed is not an accident.[67] As it was the case in so many other nations going through profound social changes, in Mexico the adoption of the metric system was decided whilst going through considerable social turmoil.

The group of liberals behind the metric law was in the midst of what they considered a revolution—which came to be known in Mexican history as the Rerform period. They pushed forward an ambitious reconfiguration of the country, crystalized in the new Constitution (sworn in February, 1857, roughly five weeks before the metric legislation was passed). They also had passed the so called "Reforma Laws," that restricted clerical privileges, reduced religious holidays, confiscated Church lands, made marriage a civil contract, made the civil registry of births, marriages, and deaths mandatory, and expanded equality before the law (reducing Church and military jurisdictions). Following the steps of the French revolutionaries, Mexican liberals of the 1850s found that equality before the law and metrological equality go hand in hand.[68] And their plan to bury customary measures was in perfect accord with their ambition to obliterate the colonial past of the young nation.

The liberals' plan to metricate the country in a period of five years suffered quickly a mayor seatback. 1857 marked the beginning of a three-year-long civil war between liberals and conservatives (known as the Reforma War). In June 1858 Melchor

[67] This new Constitution, as the one from 1824, also gave to Congress the facult to establish a general system of weitghs and measures, see *Constitución Federal de los Estados Unidos Mexicanos de 1857,* article 72, fraction XXIII.

[68] On the important topic of the linkage between the metric system and equality before the law see, Kula, *Men and Measures*, 122-123, 223-226, 267-268; Scott, *Measuring Like a State,* 32. On the more general problem of measurement and abtract equality see, George Simmel, *The Philosophy of Money* (London: Routledge, 2003), 441-446; Denis Guedj, *El metro del mundo* (Barcelona: Anagrama, 2003), 264-277.

Ocampo informed President Benito Juárez that the metric legislation would be suspended.[69] This suspension of the metric decree set the tone for what was to come in the next 40 years, when every new piece of legislation mandating the metric system was followed shortly by a new provision postponing it.[70]

And things got quickly worst. In 1864 began the Second Mexican Empire, with Austrian Maximilian I as emperor, backed by Napoleon III. Maximilian, who received the support of Mexican conservatives, decided to restart the metric policy. The first Mexican decimal coins were coined during these years, bearing a portrait of Maximilian.[71] His government even signed an initial contract for the fabrication of metric standards to supply the whole the empire.[72] This should not come as a surprise. As we saw in the previous chapter, French colonialism was one of the main motors in the international diffusion, and Mexico's case should be partially added to that list. But the Empire was handicapped by the same structural limitations that prevent the republic to go forward with the metrication plan.

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[69] AGN, Pesas y medidas, box 1, exp. 1; also "Decreto que suspende los efectos de la ley que estableció el sistema métrico-decimal francés," in *Legislación mexicana,* Manuel Dublán and José María Lozano, eds. (Mexico: Imprenta del Comercio, 1877), 8: 656.

[70] The several metric legislations passed during the nineteenth century dated 1857, 1861, 1865, 1878, 1882, 1883, and 1895. AGN, Pesas y medidas, box 2, exp. 17; Héctor Nava and Felix Pezet, *El sistema internacional de unidades* (Querétaro: Cetro Nacional de Metrología, 2003), 117-118.

[71] On the history of decimal currency in Mexico, see Miguel L. Muñoz, "The Decimal Monetary System, Its Adoption in Mexico," 273-289; Richard G. Doty, "Juaristas, Imperialistas, and Centavos: Decimalization and Civil War in Mexico, 1857-1870," *American Journal of Numismatics* 3-4 (1992): 135-146; José Manuel Sobrino, *La moneda mexicana: su historia* (Mexico: Banco de México, 1989), 99-103.

[72] *Memoria presentada a S. M. el Emperador por el Ministro de Fomento Luis Robles Pezuela de los trabajos ejecutados en su ramo el año de 1865* (Mexico: Imprenta de J. M. Andrade y F. Escalante, 1866), 3-4, 170-176.

When the second Empire came to an end, in 1867, and the liberals regained control of the country, a decade had passed since the metric system legislation was first passed, but almost no progress was made. And the situation did not change much in the next three decades.

The Metric System and the Porfirio Díaz Regime

Strictly speaking, the actual introduction—beyond the official adoption—of the decimal metric system was the work of president Porfirio Díaz's regime. This was not a coincidence, as it was during those years that the first Mexican state, in the proper sense, was founded.[73] Switching a whole country to a new measurement system was a thorny enterprise and only a fully functional state could undertake such a task (the numerous failures to do it from 1857 to 1895 can testify to that fact); and such a state did not exist until the final part of the nineteenth century.

The federal administration during the Díaz presidency was far more effective than previous regimes in enforcing the law and had better finances to support its public projects. And it had also two important advantages that were not available years before: the telegraph and the railroad. The former helped the Ministry of Development to be in constant communication with state governors to supervise the progress made in the adoption of the new measures; the latter made the visits by inspectors of weights and measures across the country a tangible reality, making them more effective in overseeing

[73] Mauricio Tenorio and Aurora Gómez, *El Porfiriato* (Mexico: Fondo de Cultura Económica, 2006), 21.

the activities of the local verifying offices nationwide.

At the same time, the international presence of the metric system had increased considerably. By then almost all continental Europe and Latin America had adopted it (and it was known that there were serious plans to do so in the United States). The Diaz regime was interested in connecting Mexico with the "most advanced countries of the world," and the introduction of the metric system was seen as a way to enhance commercial and intellectual exchanges with those nations—as well as an instrument to "civilize" Mexico, as I will show later on.

These ideas gained force in the First International Conference of American States, held in Washington in 1889-1890. Among the topics discussed in the Conference included: the foundation of an American Customs Union; improving communication among the countries of the continent; the adoption of a common silver coin in all the nations; passing laws to protect copyrights; international law; transoceanic communication, classification and valuation of merchandise, and the adoption of a common system of weights and measures. A single global market was emerging, where manufactured products became more and more important in comparison with raw materials. This required an international system of measures to produce standardized commodities that fit the technical requirements of both the producer countries and consumer countries. A weights and measures commission was formed in the Conference and it issued the recommendation that all nations whose representatives held a seat at the conference should either adopt the meter or complete their transition.[74] As attending country Mexico agreed to continue its effort towards that goal, which kick started a series of evaluations and ideas to institute a new weight and measure law (I will return to this crucial episode in the next chapter). It was this ambitious plan of continental free market and economic integration outlined in the Pan-American Conference what gave the Mexican government the determination to pay the costs and confront the inconveniences of finally introducing the metric system.

In 1890 Mexico signed the Treaty of the Meter and purchased meter and kilogram standards to the International Bureau of Weights and Measures (BIPM). With that acquisition Mexico became one of few countries possessed such high-end metrological tools. All this was prepared for many years, and for the government represented a significant but expensive achievement. The official standards were very costly and a yearly fee had to be paid to the BIPM, as was demanded for all signing countries of the treaty.[75]

Plans for all of this began way back in 1883, when the Mexican government commissioned Francisco Díaz Covarrubias—an engineer well informed in technical matters of metrology and who had prepared conversion tables between metric and customary units in the 1860s—to study the Buro's functioning. The signing of the treaty

[74] International American Conference, "Report of the Committee on Weights and Measures," in *Reports of Committees and Discussion Thereon* (Washington: Govt. Print. Off, 1890), 77-80.

[75] Just in 1891 the Mexican government had to pay 57,566 francs to the BIPM due for the copies of the meter and kilogram, and its affiliation to the Treaty of the Meter. Adolfo Duclós Salinas, *The Riches of Mexico and its Institutions* (St. Louis: Nixon-Jones Printing Co., 1893), 146-147.

took place on December 30, 1890, and Mexico got awarded the kilogram number 21 which arrived to the country from Paris in 1891, and the meter number 25, which was received on 1895[76] (they became the official national standards by a legislation passed in 1905).[77]

Affiliation into the BIPM and obtaining copies of the metric standards from the international body were a great occurrence to national metrology. Personnel in the Bureau of Weights and Measures were aware of the extraordinary opportunity of having those instruments and proper precautions were taken for the tool's safekeeping. The kilogram 21 and meter 25 were held in the Bureau's premises. An iron box was purchased to store them and a fancy department store was commissioned to condition two rooms so to have them properly set up "to allow for the national standards to be officially turned in"[78]—the purchase of the iron box eventually proved its worth when in September 1985, in the aftermath of a massive earthquake that leveled downtown Mexico City, the building where the standards were kept collapsed, but the box was rescued from beneath the rubble with the platinum-iridium kilogram and meter laying intact.[79]

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[76] Departamento de Pesas y Medidas, *Prototipos nacionales de metro y kilogramo* (Mexico: Oficina Tipográfica de la Secretaria de Fomento, 1901).

[77] "Ley de 6 de junio de 1905 sobre pesas y medidas," in *Constitución federal con todas sus leyes orgánicas y reglamentarias,* ed. Juan de la Torre (Mexico: Antigua Imprenta de Murguia, 1907), 466-472; "Reglamento de ley de 6 de junio de 1905 sobre pesas y medidas," in *Manual práctico de la constitución,* ed. Antonio J. de Lozano (Mexico: Herrero Hermanos, 1906), 381-438.

[78] AGN, Pesas y medidas, box 6, exp. 2 and 6.

[79] I own part of this information to Félix Pezet, who was one of the persons in charge of rescuing the iron box. On the history of kilogram 21 see Nava and Pezet, *El sistema internacional de unidades* (Queretaro: Cetro Nacional de Metrología, 2003), 144-147.

The culmination of this process was a new metric law, passed on June 16, 1895.[80] This time the Mexican state was determined and prepared to make good on it. The economic landscape, both within and outside the country, asked for the standardization of weights and measures; thriving world commerce and growing economic integration amongst the different regions in the country claimed for a common language to quantify, gauge, and value trading products. At the end of the nineteenth century the metric system held a firm footing globally, with more and more countries adopting it.

So it was decided, under the guide of the Ministry of Development, that on September 16, 1896 the metric system would be the sole legal system of measurement in the country and that those not abiding—either by the employment of non-metric measures or owning non-certified tools—would face a steep fine. In charge of the Ministry at the time was the renowned engineer Manuel Fernández Leal, a man well known in the scientific circles and who had worked in some of the most relevant engineering projects in the country. Working for him, heading the Bureau of Weights and Measures, there was another geographical engineer, Ezequiel Pérez, a methodic man of science and a relentless bureaucrat. Together they guided the state efforts to finally make reality the forty-years-long plans to metricate Mexico.

And so the state machinery started working to instill the meter, litter, and kilogram into the economic and social life of the nation. A titanic effort was made to distribute among the population copies of the new metric legislation along with

[80] *Ley sobre pesas y medidas de 19 de junio de 1895 y reglamento de la misma ley* (Mexico: Oficina Tipográfica de la Secretaria de Fomento, 1896).

instructional handbooks. The government ordered the importation, manufacture, and commercialization of hundreds of thousands of weights, scales, steelyard balances, measuring rods, and other metric equipment so merchants throughout the country could buy the new instruments. The Ministry of Development made sure that every municipality had at least one properly equipped verification office, and trained agents and inspectors to make verifications, who soon enough began their work by overseeing the daily trades of merchants fining those who kept employing non-metric measures. Finally, in an attempt to incorporate the citizenry in this process of everyday state formation, the Ministry asked for the collaboration of individuals well versed in mathematics and technical matters to help their fellow citizens to grasp and accept the new system dictating public lectures and printing leaflets—and some indeed answered the call, as I will show in chapter four.

The success on these policies was overall palpable, though rather uneven, with cities making the transition to metric faster than villages and rural areas.[81] During the initial weeks of the campaign a major problem halt the official efforts. Contrary to what had happened in previous occasions this time the government equipped itself sufficiently, but the production of metric standards and instruments to supply the population was largely insufficient. Traders flooded with letters the Ministry and newspapers asking for an extension on the deadline because suppliers of metric equipment had run out.[82]

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[81] See for example AGN, Pesas y medidas, box 75, exps. 5 and 7.

[82] See *El Tiempo,* September 16, 1896. Aslo, AGN, Pesas y medidas, box 4, exps. 3 and 5, and box 11, exp. 6-7.

Beyond this setback, the camping advanced slowly but steadily and laid a solid base for a complete metric transition—a transition that actually needed a few more decades to be completed, but the process had finally started.

In his 1904 Address to Congress, Porfirio Díaz claimed that "the decimal metric system has taken definitive root in the country, and the final obstacles for tis generalization have been sorted out."[83] This announcement was premature and overoptimistic, but the progress made in the previous eight certainly gave the president reasons to feel good about their job, despite all the trouble that had gone through.

Scientific Gibberish: The Difficult Dissemination of the Meter

In 1897 an outraged citizen complained in a letter to the Ministry of Development, "Throughout my travels around the Republic I have seen the metric system being entirely set aside in commerce. In ranches they may have heard of it, but only as a mere theoretical curiosity. In municipalities the authorities let merchants to sell using old measures and to weigh with duodecimal weights. I have never heard of a single fine imposed due to these infractions. […] An inspector with the help of one assistant, visiting by surprise shops and stores, would charge dozens of fines."[84] The ideas, aspirations, and goodwill that scientists and administrators had in advancing a scientific measuring

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[83] *Informe del ciudadano general Porfirio Díaz presidente de los Estados Unidos Mexicanos a sus compatriotas acerca de los acontecimientos de su administración en el periodo constitucional comprendido entre el 1 de diciembre de 1900 a 30 de noviembre de 1904* (Mexico: Imprenta del Gobierno Federal, 1904), 118-119.

[84] Letter from Benigno Castillo to the Secretario de Fomento, March 31, 1897, AGN, Pesas y medidas, box 114, exp. 1.

system hit headfirst against public indifference, people who had no issues with their customary measurement system. The metric system was for them just a meaningless curiosity. Thus, even though the insertion of the metric system was largely achieved in commercial activities, the gap that separated men of knowledge and common folk in regards of the meter system took decades to close.

Many a time clerks in charge of reporting the advances made in introducing new units did not know themselves how to use the metric system. In 1896 an agent informed to the federal government that in the municipality of Comitán, aguardiente was still being sold by the flask—instead of liters—and that each flask "is equivalent to 2 liters and 455 grams [sic],"[85] wrongly mixing units of volume (liters) and mass (grams). Such between mass and volume had to be very common then. In other government offices, like courts, clerks did not even try to use the new legal measures and they published sentences regarding terrains simply using customary measures.[86]

One of the main issues the advocates of the metric system had at the time was that it was not self-evident that the metric system was an improvement from what already existed. It was manifest for anyone that a train was more powerful than a carriage or that the telegraph delivered messages faster than mail. For engineers and astronomers it was clear that the meter was superior to the *vara*, but for barmen and drunken *tinajas, odres,* and *cubos* were as good—or better—than the liter when it came to measuring *pulque* and liquor.

[85] AGN, Pesas y medidas, box 10, exp. 3.

[86] AGN, Pesas y medidas, box 14, exp. 2.

For men on the street and small merchants the measurement reform was the cure for something they did not consider to be a disease. On September 16, 1896, the day when the metric law came into effect a newspaper complained that "for a long time people will ask the butcher for two *kilometers* of ribs, and in popular gatherings in the *barrios* people criticize that scientific gibberish that complicate simple things just for the sake of wisdom."[87]

Another problem faced by the Ministry of Development was the impossibility to monopolize diffusion of information about the metric system. The laws to impose the system, ineffective as they were, generated certain curiosity among some people for knowing what the meter was, and how it was used. This curiosity became an opportunity for publishers to print and sell instructional leaflets, handbooks, and textbooks aim to teach people the basics about the metric system. At first, what seemed to be an aid to the government in distributing knowledge and information, turned into a nightmare, as these unofficial printed materials were plagued with technical inaccuracies which multiplied confusions and misunderstandings.[88] So now the state had to deal not only with overcoming people's general lack of knowledge and interest about the metric system, but also the unintended disinformation campaign carried out by well-intentioned publishers. In other words, the state struggled to monopolize the process of social distribution of knowledge.

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[87] *El Tiempo,* September 16, 1896.

[88] See AGN, Pesas y medidas, box 4, exp. 2.

Despite all these difficulties the metric campaign made real progress. Inspectors of weights and measures were not always reliable in their tasks—not all commercial establishments were inspected, and abuses and corruption were frequently reported[89]—but they did work and did impose thousands of fines to negligent vendors. By looking at the penalty records of the verifying offices in Mexico City, for example, it comes clear that small commerce (ironmongers, notions stores, pharmacies, taverns, grocery stores, butcher shops, mills, and so on) had made a full transition to the metric system by the beginning of twentieth century. Plenty of shops and stores were fined by the inspectors—who always made their visits accompanied by a police man—but the great majority of these fines involved metric scales or instruments not properly verified—instead of the use not for the use of non-metric weights or measures.[90]

Post-Revolutionary State

During the years shortly after the 1910 revolution the federal government did not show much effort to complete the introduction of the metric system. The revolution brought a new Constitution, which—like its predecessors on 1824 and 1857—gave to Congress the faculty to "establish mints, fix the standards of coins and coinage, to determine the value of foreign currencies, and to adopt a general system of weights and

[89] See for example, AHDF, Pesas y medidas, vol. 3607, exp. 185; "Servicio de pesas y medidas," *Actualidades*, March 12, 1902.

[90] AHDF, Pesas y medidas, vol. 3606, exp. 136-168.

measures."[91] But only during the presidency of Plutarco Elias Calles those efforts were renewed, in the wake of a new weights and measures legislation, passed on June 14, 1928.[92]

A preamble of this was given in 1922 when Mexico joined the international time-zone system. Although Mexico had taken part in the International Meridian Conference of 1884, held at Washington DC, the country did not put in effect Greenwich time as its point of reference. The official time was rather given in accord to the "Tacubaya Meridian" (also known as "railroad time"), as was given by the National Observatory, to set the work of the telegraph and railroad systems. This interest by the Mexican government to get in sync with international conventions was then expanded to weights and measures.

The 1928 law brought some changes to move forward the use of the metric system in commerce. In particular it applied more pressure to control goods coming into the country, forcing importers to display the information in the product labels using metric units, instead of the units from the countries were those commodities were made. Obviously this disposition affected specially United States exporters because most of the others countries that did business with Mexico had already switched to metric.[93] In the past customs let foreign goods to enter the country even if quantities were marked in

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[91] *Constitución política de los Estados Unidos Mexicanos,* article 73, fraction XVIII.

[92] Further legislation was passed during the twentieth century, most notably on 1961 ("Ley general de normas y de pesos y medida"), 1988 ("Ley federal de sobre metrología y normalización"), and July 1992 ("Ley federal sobre metrología y normalización").

[93] *The New York Times,* February 2, 1930: 48; *El Informador,* July 22, 1929: 3.

pounds, pints, or other units from the English system; now it was expected that all imported goods would came with dual labeling, metric and English units.

Later on state officials decided to carry out another provision of the law which asked for packages to express the exact amount of units they contained. For example, boxes should say "twelve eggs" or "144 bottles," instead of saying "a dozen eggs" or "a gross of bottles." In other words, the law was banning of use of concepts for grouping units—the only exception was the term "pair," but it could be used in certain goods such as gloves or socks.[94] The aim of this regulation was to inhibit the use of the number twelve in calculations and metal grouping, because the duodecimal system hindered the development of decimal quantification. This was, in other words, an attack on the arithmetic habits of the people.

A third area where the new regulations were actually implemented was advertising. The law banned storekeepers to have any kind of posters, signs, or propaganda displaying non-metric units. Offenders were now fined more systematically than before. These legal dispositions helped to wear down some of obstacles that had halted metrication in the country. But much work was still needed.

Counting Measures: the 1930 Agricultural Census

Thanks to renewed interest of the Mexican government to complete the metrological unification in the territory, in the late 1920s it carried out the most ambitious

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[94] *The New York Times,* November 9, 1937: 16.

research ever made in Mexico regarding weights and measures. As part of the works of the 1930 census of agriculture, farmers and peasants were asked about the extension of their plots, their harvesting areas, and the amount of product obtained; when they could not answer these questions using the metric system—which happened rather frequently—they were allowed to indicate those quantities with the customary units of their own region. In those cases, the personnel of the Census Bureau made the computations to define the equivalences between customary and metric units.[95]

The results of this titanic work were published by the Ministry of Economy in 1933 in a volume titled *Medidas regionales* (Regional measures).[96] And a couple of years later, government agents returned to the field to verify and fine-tune the information obtained in the census. The result was a second compilation of data that was made public in a second version of *Medidas regionales*, published in 1937, with three times more information than the first edition.[97] This metrological census helped to know in great detail, for the first time, what was the real status of metrication in the country—forty year after the first effective metric campaign was launched. The findings were discouraging.

In 31 (out of 32) states in the country, the existence of non-metric measures was recorded. In total 244 different units of measurement were listed in the whole country.

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[95] On the Mexican state and the 1930 census see Michael Ervin, "The 1930 Agrarian Census in Mexico: Agronomists, Middle Politics, and the Negotiation of Data Collection," *Hispanic American Historical Review* 87 (2007): 537-570; and Michael Ervin, "Statistics, Maps, and Legibility: Negotiating Nationalism in Post-Revolutionary Mexico," *The Americas* 66 (2009): 155-179.

[96] Dirección General de Estadística, *Medidas regionales* (Mexico: Secretaría de la Economía Nacional, 1933).

[97] Dirección General de Estadística, *Medidas regionales* (Mexico: Secretaría de la Economía Nacional, 1937).

The entire range of units used in colonial times appeared alive and kicking on the records of *Medidas regionales*. It seemed like in some municipalities the metric system had not existed at all. For dry measures *carga, fanega*, *almud* and the like were still there; for liquids: *barrica, barril, botija, toro, chochocol,* etcetera; for flow units: *buey, naranja, real*; for length: *cuerda, vara, mecate, cordel*; for surface: *caballería, solar, criadero de ganado, fundo, parcela*; and a myriad of other measures whose names today hardly relate for an Spanish speaker to units of measure: *perra, sarta, tajo, chavo, yunta, tarea, mazo, acción, cubo, maquila, mano, haz, labor, topo, madeja, jícara, atado, garrapata, estado, cajón,* and many more.

Some of these weights and measures were only used in some towns and provinces, but others had actually a nationwide scope—particularly dry measures such as *fanega* and *almud*. Not only it was troubling to realize that there were more than two hundred old units of measurement circulating among the rural population (which at that time was the vast majority of the population); additionally, there were many variations on their magnitudes—i.e. units with the same name had actually different sizes from town to town. Considering these regional variants, the census listed over 15,000 variations. For example, in three municipalities in the center region of the country a *cuerda de leña* was equal to 10 m^3 in Atlacomulco, 3.6 m^3 in Huixquilucan, and 1 m^3 in Ixtlahuaca. All doubts about the lack of uniformity among the customary measures in Mexico were convincingly confirmed. Customary measures seemed to be indestructible. After decades of work to bring the metric system to the people there was still too much to be done.

But these issues were not as severe in all regions of the country; some states were in worst shape than others, in terms of their progress implementing the metric system. In the northern states the lack of standardization was not as stiff compared to the rest of the country. The wealth of the surviving colonial measures was concentrated in a region from the states of Jalisco and Veracruz, to Chiapas; nine out of ten states with the highest number of non-metric measures were in this geographic block (the tenth was Yucatán). Among these, Puebla, Veracruz, and Oaxaca were the least homogeneous, not only were these the states with the highest amount of units of measurement but they also showed the highest variations per unit. Oaxaca in particular was extraordinarily rich in metrological diversity, 71 units of measurement with 3,230 variations (averaging 45 variations per unit).

The data of the census indicates that even if the metric system had made important advances among the urban population, in rural areas the colonial units of measurement were widely used. A newspaper editorial, in the state of Jalisco, claimed that "in the states, or at least in ours, there have been many years since nobody talks of *varas, libras,* and *reales*. People younger of 25 years old have no idea of what a *cuartillo* was, not how much three *tlacos* are."[98] Assertions like this may give some idea of what was happening among the urban youth; but when contrast with the census information assertions like this appear too optimistic. According to the census, Jalisco itself was one of the top five states with the largest number of non-metric units were registered (51 in total).

[98] *El Informador,* May 28, 1926.

Are the results of the 1930 census a sign that the policies to introduce the metric system in Mexico were disastrous? Not necessarily. The data certainly shows that the government's projects hardly ever fulfilled their ambitious objectives. But contrasting Mexico with other countries that also tried to go metric system during the nineteenth century, it can be said that the Mexican transition was not particularly calamitous. Although not so much is known in detail about how quickly or effectively the policies progressed for introducing the meter in many European countries (where the metric system was adopted more or less at the same time as in Mexico) studies show that there were similarities with the Mexican case.[99] First, despite the fact that several decades have passed since the official implementation of the new system, the conversion had not been completed even in the first third of the twentieth century. Second, it was also in the rural areas where customary measures were most tenaciously rooted. Not even in its native France the metric measures had displaced entirely the medieval units more than a century after the transition had begun.[100]

The Last Crusade

After the appearance of the second volume of *Medidas Regionales*, in 1937—during the administration of emblematic president Lázaro Cardenas—it was decided to give a last push to finish the introduction of the metric system. In that year the

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[99] Arthur Kennelly, *Vestiges of Pre-Metric Weights and Measures Persisting in Metric-System Europe 1926-1927* (Nueva York, Macmillan, 1928).

[100] Kennelly, *Vestiges of Pre-Metric Weights and Measures,* 28-55; Eugen Weber, *Peasants into Frenchmen* (Stanford, Stanford University Press, 1976): 30-33.

government printed new propaganda promoting the use of metric units. One of those materials handed out to the public was the booklet *El uso de un solo sistema de medidas*—this text, like *Medidas Regionales,* was produced by the General Bureau of Statistics, in the Ministry of Development.

In this new generation of government advertising materials to promote the meter, the arguments justifying its importance changed regarding what had been done in the nineteenth-century campaigns. By now, the metric system had lost much of its scientific aura, it was no longer an innovation that would astonish intellectuals and scholars. This time around scientists and engineers were not leading the campaign. In the scientific world the meter was at that point a given thing, with no need to be publicized. The new campaign did not pressed either on what measurement systems the "civilized nations of the world" employed. A new set of values were married to the metric system.

Now the main concern was the "increased complication on human activities" that required having uniform and accurate measures. The government's literature illustrated this idea, for example, with the progress made in time measurement with the increased accuracy gained by replacing old customs (such as reckoning time by looking at the sun's position over the horizon) with clocks. The now more generalized habit among the population of "knowing the weight of one's body as a source of monitoring the physical condition of a person," was also mentioned as an illustration of this tendency.[101] In general, the argument to justify the use the of the metric system shifted from appealing to

[101] Dirección General de Estadística, *El uso de un solo sistema de medidas* (Mexico: Secretaría de la Economía Nacional, 1937), 6, 9.

ideas like civilization and science (as in the nineteenth century), to a more nationalistic and pragmatic view.

The government priorities to keep pushing the metric's reform were clearly stated in *El uso de un solo sistema de medidas*, particularily around the crucial role of state statistics. The brochure recalls that to standardize the "great many number of measures gave by the farmers" in the 1930 census,

> a great collective effort was required, just the calculations summed up to more than three million, that amount of operations represents such an arduous effort that if only one person should do that alone, armed with a modern electrical calculator, would need to work at least 25 years nonstop until he would finish. *This circumstance alone should be enough to recommend the generalization of a sole measurement system,* as the agricultural census is to be performed every ten years and it is certain that the data or information that farmers will provide is going to grow steadily. These censuses would be cheaper and the final results more readily obtained if the great number of regional measures of weight, volume, and area were eliminated.[102]

Practicality, of course, is in the eye of the beholder. No wonder this publication was made by the Bureau of Statistics presents the standpoint of the petit-bureaucrats who spent countless hours calculating the equivalences between liter and *fanega* in Fresnillo, Los Tuxtlas, Cacalchén, and hundreds of other towns. For state agents the widespread use of the metric system represented an efficient tool to process information about the country's productive capacity and this was, from their perspective, something good in itself. Needless to say that for the millions of Mexicans that were asked to forsake the

[102] Dirección General de Estadística, *El uso de un solo sistema de medidas,* 14. Emphasis added.

measures they grew up using it was preferable that a handful of pencil pushers work long hours in their calculators than to pass themselves for the fastidious process of learning the metric system.

In general, the message of this new campaign emphasized the application of a *sole* system of measurement, would this be the decimal metric or another one seemed like a secondary issue. It was *uniformity*—so useful for the census and other state matters—what stood out. With their eyes in the 1940 census, the personnel of the Bureau of Statistics was under pressure to lessen its work load and avoid the numerical quagmire produced by metrological diversity. So they tried to put in effect a "wide, systematic, and long-lasting campaign" to convince people of the problems caused by the lack of standardization, and persuade peasants, industrialists, craftsmen, consumers, and students to observe the metric legislation. The ministries of Economy, Education, and Agriculture participated in the campaign.

Another kind of brochure came out for this new metric crusade, with a more pedagogical content, illustrated with drawing and chars, like the booklet *Los censos y el sistema métrico decimal: abandone las medidas anticuadas* (The census and the metric system: abandon customary measures!) While this pamphlet was addressed to a wider public, it also had a highly ideological content which linked the meter with Mexico's progress and unity. The slogan "Be progressive, leave behind the old-fashioned measures and adopt the decimal metric system!" could be read in the covers. It appealed for citizens to become daily actors of progress who would improve the country with their everyday actions. It called for teachers, traders, farmers, municipal authorities, and citizens to promote the metrication campaign.

The launching of "Pro-Metric Propaganda Committees" was promoted, urging these voluntary groups to write letters, sketch posters, and lecture in public places to convince others to leave behind the old measures. The Bureau of Statistics stock the committees with brochures and printed materials. The two main ideas in this propaganda were *progress* and *national unification*. For instance,

> The country's unity would gain much if all the people that only know an indigenous dialect could speak also the national language—i.e. Spanish or Castilian. The same benefits can be obtained if the vast diversity on weights and measures which still prevails in small populations disappears and all inhabitants use the sole legal system of weights and measures—the decimal metric system. The social and economic benefits of this would be of great consequence for the republic, as it would also strength its unifying factors; unification is power, power means better organization, a leap forward in collective life.[103]

This argument stressed that progress and national cohesion were hand in hand:

> The kilogram and the hectare will be enthusiastically adopted by progressive peasants, as they know that the kilogram and the hectare are used all across the country, they are national measures that all Mexicans should know and use. Today Mexico's national unity is strengthening; peasants from different regions have become acquainted and understand each other better; regional differences and local quarrels, which bring nothing good, are forgotten, and it only remains the natural beauties, and the songs and dances of every region. At the same time, farmers work more, drink less, attend school in greater numbers, go more often to the physician and live better. […] The unification of the nation

[103] Dirección General de Estadística, *Censos y el sistema métrico,* 6-7.

and the progress of the Mexican people demand that there should be a single system of weights and measures for the whole country. [104]

It is hard to determine how effective this campaign ultimately was; but considering the ideas and values that it wanted to spread, and the materials used to carry it out, probably it had a rather moderate impact among the targeted populated—people living in rural areas who had been unreceptive to the metric system.

This campaign marked the end of the large-scale endeavors of the Mexican state to metricate the country. Of course, that was not the end of the administration and regulation of weights and measures, which is an ongoing, never-ending task (i.e. the process of maintaining and reproducing a certain cluster of ideas in the social stock of knowledge). And during the latter part of the century there were some important events, like the creation of the National Center of Metrology, which responded to the technical needs brought by the North American Free Trade Agreement between Mexico, Canada and the United States—an episode I will address in the next chapter.

Now is time to see how Mexico's northern neighbor state tackled the problem of governing weights and measures.

3. STATE AND MEASUREMENT IN THE UNITED STATES

On January 6, 2011, for the first time in the history of the United States Congress, members of the House of Representatives read the Constitution on the floor of the House chamber. The idea for this event was proposed by Representative Robert Goodlatte, who

[104] Dirección General de Estadística, *Censos y el sistema métrico*, 10.

explained that "Throughout the last year there has been a great debate about the expansion of the federal government, and lots of my constituents have said that Congress has gone beyond its powers granted in the Constitution."[105] This sentiment is not novel; as Theda Skocpol points out, throughout America's history there has been a "continuing ambivalence of most citizens about the proper—or possible—role of concentrated authority in national life."[106]

In the midst of this prolonged political battle about the legitimacy of federal government actions—with many arguing that Congress has assumed powers that are not explicitly mentioned in the Constitution—it is worth noting that Congress has been reluctant to exercise one of the powers that the Constitution actually gives it. The charter indicates that Congress "shall have power… to coin money, regulate the value thereof, and of foreign coin, and fix the standard of weights and measures."[107] In the unwillingness of the federal government to use this constitutional measure and to act decisively to set weights and measures lays one of the keys to understanding why the Unites States has not fully adopted the decimal metric system—and why it has been left behind in a metric globe.

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105 Jennifer Steinhauer, "Constitution Has Its Day (More or Less) in House," *New York Times*, January 7, 2011.

106 Theda Skocpol, *Social Policy in the United States* (Princeton: Princeton University Press, 1994), 33.

107 *Constitution of the United States*, article 1, section 8, clause 5. See also Jay Wexler, *The Odd Clauses: Understanding the Constitution through Ten of Its Most Curious Provisions* (Boston: Beacon Press, 2011), 21-38.

Here I will trace the multiple and ill-conceived attempts of the United States government to lead a national effort in favor of metrication.[108]

All in all, there are three periods in the United States history that are particularly relevant in the analysis of the federal government's efforts to regulate weights and measures and to make a full transition of the metric system:

- 1777-1836, the first decades of the Republic, from the *Articles of Confederation* to the Weights and Measures Act of 1836.
- 1866-1893, from the Reconstruction era to the final decade of the century, punctuated by the Metric Act of 1866 and the so called "Mendenhall Order" (1893).
- 1968-1982, a period that revolved around the Metric Conversion Act of 1975 and culminated with the disbanding of the US Metric Board during the Reagan administration.

[108] Among the many accounts of the history of weights and measures, and the metric system in the United States, see: Ralph W. Smith, *The Federal Basis for Weights and Measures: A Historical Review of Federal Legislative Effort, Statutes, and Administrative Action in the Field of Weights and Measures in the United States* (National Bureau of Standards Circular 593. Washington: National Bureau of Standards, 1958); Edward Franklin Cox, "A History of the Metric System of Weights and Measures: With Emphasis on Campaigns for its Adoption in Great Britain and in the United States prior to 1914" (PhD diss., Indiana University, 1956); Charles F. Treat, *A History of the Metric System Controversy in the United States* (Washington: National Bureau of Standards, 1971); Ellen Watkins, "Measures of Change: A Constructionist Analysis of Metrication in the United States" (PhD diss., Southern Illinois University, 1998); Louis Albert Fischer, "History of the Standard Weights and Measures of the United States," *Bulletin of the Bureau of Standards* 1 (1905): 365-381; Sarah Ann Jones, "Weights and Measures in Congress: A Historical Summary of Events Culminating in the Weights and Measures Act of 1836" (M.A. Diss., George Washington University, 1935); Lewis Judson and Louis E. Barbrow, *Weights and Measures Standards of the United States: A Brief History* (Washington: National Bureau of Standards, 1976); Arthur Frazier, *United States Standards of Weights and Measures, their Creation and Creators* (Washington: Smithsonian Institution Press, 1978); Arthur McCourbrey, "Measures and Measuring Systems," in *The Encyclopedia Americana. International Edition* (Danbury: Grolier, 1993), 18: 584-597; Frank Donovan, *Prepare Now for a Metric Future* (New York: Weybright and Talley, 1970), 80-109; Richard Deming, *Metric Power: Why and How We Are Going Metric* (Nashville: Thomas Nelson Publishers, 1974), 21-34.

I will focus my attention primarily in these three periods, and I will finish with an examination of the two main reasons that have prevented the introduction of the metric system in America: the unwillingness to pass *compulsory legislation* and the lack of a *centralized metrological apparatus*.

Colonial America: A Metrological Melting Pot

The European immigrants who arrived to North America brought with them extraordinary metrological diversity, with groups from different parts of the old continent maintaining their local measures. This reproduced in America the European problems that resulted from a lack of standardization. It has been estimated, for example, that in eighteenth-century Europe there were 319 units called *pound,* and 282 units named *foot,* all of them different in their respective magnitudes.[109] In the colonies, there was a coexistence of measures from Scotland, Ireland, England, Germany, and other countries, plus their local variations. It has been suggested that 100,000 measures coexisted in the thirteen colonies[110]—a very high number, but a plausible one considering, for example, that in eighteenth-century France alone there were approximately 250,000 measures (i.e.

[109] Herbert Wade, "Weights and Measures," in *Encyclopaedia of the Social Sciences* (New York: The MacMillan Company, 1930), 15: 390. There are several directories of ancient measures, one of the more detailed is Robald Zupko, *French Weights and Measures before the Revolution: A Dictionary of Provincial and Local Units* (Bloomington: Indiana University Press, 1968).

[110] That number is mentioned by Andro Linklater, *Measuring America* (New York: Walker and Company, 2002), 104; unfortunately he does not cite any authoritative reference. A. Hunter Dupree has suggested the hypothesis that the colonies "had less diversity in their measurement system than any country in Europe," but he does not offer evidence to support that claim—see his article "Measurement," in *The History of Science in the United States: An Encyclopedia,* ed. Marc Rothenberg (New York: Garland Publishing, 2001), 339.

700 units with distinct names, plus their local variations).[111] It is not difficult to imagine that this was fertile soil for mercantile frauds and also an obstacle for any kind of commerce that went beyond local markets.

The colonies acted independently in their metrological regulations—an arrangement that would cast a large shadow on the nation's future.[112] Numerous laws were introduced since early colonial days, both in England and in the colonies, to fix their weights and measures "according to the General Custom of England,"[113] but the problem persisted. The year 1776 arrived before any substantial solution could be found for this problem.

Measures in the Young Republic

The newly constituted United States of America set from the beginning some legal provisions about who would be in charge of regulating weights and measures in the country. The 1777 Articles of Confederation specified that "The United States in Congress assembled shall […] have the sole and exclusive right and power of regulating the alloy and value of coin struck by their own authority, or by that of the respective States—*fixing the standards of weights and measures throughout the United States*—

[111] Adler, "A Revolution to Measure," 43; see also See Ronald E. Zupko, *French Weights and Measures before the Revolution: A Dictionary of Provincial and Local Units* (Bloomington: Indiana University Press, 1968).

[112] Smith, *The Federal Basis for Weights and Measures,* 3.

[113] *The Colonial Laws of New York, from the Year 1664 to the Revolution* (Albany: James B. Lyon, 1894), I: 64. A large variety of documents in this topic can be seen in *American State Papers: Documents, Legislative and Executive of the Congress of the United States. Class X, Miscellaneous: Volume II* (Washington, Gales and Seaton, 1834), 538-750.

regulating the trade and managing all affairs with the Indians."[114] And, as I already mentioned, the 1787 Constitution kept this stipulation, giving Congress the power to "fix the standard of weights and measures." Of course, the Constitution granted Congress that authority, but it did not say that Congress should exercise it—and it has not, despite being repeatedly urged to do it.

George Washington, who worked as surveyor and mapmaker at the beginning of his career was well aware of the importance of fixing weights and measures and pleaded with Congress for action. In his first Annual Address, in January of 1790, Washington told congressmen that "Uniformity in the currency, weights, and measures of the United States, is an object of great importance, and will, I am persuaded, be duly attended to."[115] In his second Address, he returned to the issue, stating that "The establishment of the militia, of a mint, of standards of weights and measures, of the post office and post-roads, are subjects which I presume you will resume of course, and which are abundantly urged by their own importance."[116] And the following year, in his third Annual Address reiterated that "uniformity in the weights and measures of the country is among the important objects submitted to you by the constitution, and if it can be derived from a standard at once invariable and universal, must be no less honorable to the public councils than conducive to the public convenience."[117]

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[114] *Articles of Confederation*, article 9, paragraph 4. Emphasis added.

[115] The Addresses and Messages of the Presidents of the United States, Inaugural, Annual, and Special, from 1789 to 1846, ed. Edwin Williams (New York: Edward Walker, 1846), I: 34.

[116] *The Addresses and Messages of the Presidents*, I: 37.

[117] *The Addresses and Messages of the Presidents*, I: 42.

In 1790, in response to Washington's petition, the House of Representatives requested that Thomas Jefferson, then Secretary of State, study the subject and submit a recommendation. Jefferson had already showcased his inventiveness in tackling this sort of problem when he spoke of the question of currency (not to mention his further metrological contributions to the republic embodied in his plan for the system of apportionment of Representatives in Congress, and the Public Land Survey System).[118] In 1784 Jefferson prepared his *Notes on the Establishment of a Money Unit, and of a Coinage for the United States*,[119] which set the basis for the present American dollar. A decade before the *franc* was established during the French revolution (1795), Jefferson set the blueprint for the first *decimal* national currency in modern history—pioneering what would become one the most prevalent monetary convention in today's world. Jefferson justified this innovation, arguing that "The most *easy ratio* of multiplication and division, is that by ten. Every one knows the facility of Decimal Arithmetic."[120] He suggested that there should be a golden coin of ten dollars, a silver dollar, a silver "tenth of a dollar," and a copper "hundredth of a dollar" (i.e. a progression of 10, 1, 0.1, and 0.01). But contrary to the radical innovative spirit that characterized the French revolutionaries, Jefferson did not seek an entirely new form of money, as for him the new

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118 The Public Land Survey System was used for cadaster and literally shaped the land during the westward expansion of the country. On apportionment of Representatives in Congress see Michel L. Balinski and H. Peyton Young, *Fair Representation: Meeting the Ideal of One Man, One Vote* (New Haven: Yale University Press, 1982); on Jefferson long-lasting interest on measurement, see I. B. Cohen, *The Triumph of Numbers* (New York: W.W. Norton, 2005), 73-80.

119 Thomas Jefferson, "Notes on the Establishment of a Money Unit, and of a Coinage for the United States," in *The Papers of Thomas Jefferson,* ed. Julian P. Boyd (Princeton: Princeton University Press, 1953), VII: 175-188.

120 Jefferson, "Notes on the Establishment of a Money Unit," 176.

monetary unit should have a value "nearly of the value of some of the known coins" to facilitate the adoption by the people; to secure this condition of familiarity he proposed the Spanish dollar (actually minted in New Spain) to be the base of the American dollar. Overall, it was a creative mixture of innovation and continuity—characteristics that Jefferson would suggest again in his weights and measures reform project.

In July 1970 Jefferson presented to Congress his *Plan for Establishing Uniformity in the Coinage, Weights, and Measures of the United States*.[121] It actually consisted in two plans. The first one was a proposal to update the English customary system. The second was a novel decimal system that reorganized the progressions and subdivisions of measures and changed the magnitude of many of them, only retaining their old names—much as with his coinage plan.[122]

This decimal architecture can be seen in how Jefferson conceived the units of measurement and its subdivisions. For measures of length, he said, "Let the foot be divided into 10 inches; the inch into 10 lines; the line into 10 points; let 10 feet make a decad; 10 decads one rood; 10 roods a furlong; 10 furlongs a mile." For measures of capacity: "Let the bushel be divided into 10 pottles; each pottle into 10 demi-pints; each demi-pint into 10 metres, which will be of a cubic inch each. Let 10 bushels be a quarter, and 10 quarters a last, or double ton." And for weights: "Let the ounce be divided into 10

[121] *The Papers of Thomas Jefferson,* ed. Julian P. Boyd (Princeton: Princeton University Press, 1953), XVI: 602-675.

[122] On Jefferson's work for these reports, see C. Doris Hellman, "Jefferson's Efforts towards Decimalization of United States Weights and Measures," *Isis* 16 (1931): 266-314; I. B. Cohen, *Science and the Founding Fathers* (New York: Norton, 1995), 102-108; Linklater, *Measuring America,* 103-116.

double scruples; the double scruple into 10 carats; the carat into 10 minims or demi-grains; the minim into 10 mites. Let 10 ounces make a pound; 10 pounds a stone; 16 stones a kental; 10 kentals a hogshead."[123]

With this plan Jefferson, who followed carefully the development of metrological innovations in France (he had just returned from Paris, where he served as minister to France from 1785 to 1789),[124] beat the French to the punch, again. The decimal (metric) system of weights and measures of the revolutionaries on the other side of the Atlantic still needed two more years to be fully conceived, and three extra years to begin implementation (it was the creation of Condorcet, Lavoisier, and others that, nevertheless, became an universal language for measurement, in good part due to the kind of political regimes that their respective revolutions brought about).

It is worth stressing here that the recommendations made by Jefferson on currency and weights and measures had diametrically opposite fates. In its general nature both projects were based on the same three principles: unification (i.e., create a *single* system), simplicity, and a decimal system of progressions and subdivisions. The first project was eventually accepted, helped to set the stage for future monetary reforms around the world, and placed the United States as a pioneer in the use of decimal currencies;[125] however, the second one was ignored and started America's long-lasting attachment to

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[123] *The Papers of Thomas Jefferson*, XVI: 663-664.

[124] The similarities between Jefferson's plan with that of the French scientists appointed by the French National Assembly (what would become the metric system) is not accidental. While in Paris, Jefferson met Condorcet and other French mathematicians and astronomers who participated in the invention of the metric system.

[125] Keit Ellis, *Man and Money* (London: Priory Press, 1973), 96-97.

English customary measures. In this regard it is worth noting that regarding metrological innovation, the United States represents and interesting case not only because it did not accept the metric system, but because it never accepted any significant change of system (metric or otherwise).

The difficulties in establishing a national currency and standardizing weights and measures are very similar. The state of affairs of the monetary system was as knotty as that of weights and measures. The necessity to unify the country under a single currency was imperative. As John Quincy Adams recalled, "At the close of our war for independence, we found ourselves with four English words, pound, shilling, penny, and farthing, to signify all our moneys of account. But, though English words, they were not English things. They were nowhere sterling: and scarcely in any two states of the Union were they representatives of the same sums. It was a Babel of confusion by the use of four words."[126] And these conditions persisted for decades after the revolution.

The ultimate success of the United States federal government in establishing a territorial currency during the nineteenth century is evidence that it had the resources—political, legal, and administrative—to carry out an innovative, large-scale centralizing plan. The federal government adopted Jefferson decimal scheme, created the United States Mint (1792), banned the production and circulation of locally and privately issued money, established in 1865 an office to suppress counterfeiting (the Secret Service Division of the Department of the Treasury), and founded a solid central banking

[126] John Quincy Adams, *Report of the Secretary of State, upon Weights and Measures, Prepared in Obedience to a Resolution of the House of Representatives of the fourteenth of December 1819* (Washington: Gales & Seaton, 1821), 55.

system.[127] A monopoly on the regulation of the monetary system and on the creation and coining of money was effectively instituted—but not on the means of measurement.

In the end, Jefferson's plan for weights and measures did not trigger any definitive actions by Congress.[128] The *Plan…* ultimately became the first chapter in an enormous—and ongoing—collection of studies, hearings, and proposals ordered by the United States government (at its different levels and branches) to clarify the condition of weights and measures in the country and to determine the convenience of change and reform. Altogether, it is a compendium to which some of the best minds of the nation have contributed, and that has become, after more than two centuries effort, a full library. It is also one of the most futile collections of accumulated knowledge ever produced—so much brainpower invested, but so little to show for it.[129]

During his presidency, James Madison revisited the weights and measures problem. In his 1816 Annual Message, he stated, "Congress will call to mind that no adequate provision has yet been made for the uniformity of weights and measures also contemplated by the constitution. The great utility of a standard fixed in its nature, and founded on the easy rule of decimal proportions, is sufficiently obvious. It led the government at an early stage to preparatory steps for introducing it, and a completion of

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[127] Thomas Frederick Wilson, *The Power "to Coin" Money: The Exercise of Monetary Powers by the Congress* (Armonk, N.Y.: M.E. Sharp, 1992); on the Secret Service, Stephen Mihm, *A Nation of Counterfeiters* (Cambridge: Harvard University Press, 2007), 340-359.

[128] Deming, *Metric Power*, 21-23; McCourbrey, "Measures and Measuring Systems," 593-594.

[129] For a compass to navigate the sea of documents produced by the federal government regarding weights and measures, see Jeanette Smith, "Take Me to Your Liter: A History of Metrication in the United States," *Journal of Government Information* 25 (1998): 419-438.

the work will be a just title to the public gratitude."[130] He did not specify if the decimal system should be the metric system, the one designed by Jefferson, or another one, but he clearly was asking for a drastic overhaul of America's metrological regime. Congress asked John Quincy Adams, then secretary of state, to prepare a report on the matter.

Adams extensive and erudite report showed great praise for the metric system, saying, for example, that "considered merely as a labor-saving machine, [the metric system] is a new power, offered to man, incomparably greater than that which he has acquired by the new agency which he has given to steam. It is in design the greatest invention of human ingenuity since that of printing."[131] But for him, it was not a completed product and ought to be perfected. Adams thought that its introduction in the United States would create more problems than it would solve. This position is understandable, because what Adams was seeing at the time in Europe was discouraging. In those years the metric system was only being used in a mixture with the old regime measures (thanks to a reform by Napoleon in 1812 that survived until 1837, when the full system was restored) and very little had been actually done in terms of metrication in the rest of the continent. When Adams wrote his report it was not foreseeable that the metric system was on its way to global acceptance.

In the end, despite his interest for a reform of weights and measures based on some of the same principles behind the metric system, Adams suggested to Congress a two-part plan: "1. To fix the standard, with the partial uniformity of which it is

[130] *The Addresses and Messages of the Presidents*, I: 335.

[131] John Quincy Adams, *Report upon Weights and Measures* (Washington: Gales & Seaton, 1821), 91.

susceptible, for the present, excluding all innovation. 2. To consult with foreign nations, for the future and ultimate establishment of universal and permanent uniformity."[132] It was an interesting compromise between the present state of affairs and a more perfect future; and between keeping whatever unity of measures existed in the country at the time and the need to cooperate with other countries to establish a permanent international system. At the end of the day, Adams did not think that the metric system, in spite of all its theoretical virtues, would be the answer for "universal and permanent uniformity"—in hindsight, he obviously underestimated it. Toward the end of his report, Adams offered this moral, "If there be one conclusion more clear than another, deducible from all the history of mankind, it is the danger of hasty and inconsiderate legislation upon weights and measures."[133] This marked one of the biggest differences between the ways in which the American and French revolutions approached metrological reform. The French were in a rush to shape the future, and were not timid at the moment to enforce their will. Americans chose to wait and see, and never showed much resolve to force the issue.

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[132] Adams, *Report of the Secretary of State, upon Weights and Measures*, 133.

[133] Adams, *Report of the Secretary of State, upon Weights and Measures*, 134. To Adams' credit, when he became president, he advocated cooperation with other nations to find a definitive system. So, for example, in his first Annual Message (1825), he said to Congress that "The establishment of a uniform standard of weights and measures was one of the specific objects contemplated in the formation of our constitution ; and to fix that standard was one of the powers delegated by express terms, in that instrument to Congress. The governments of Great Britain and France have scarcely ceased to be occupied with inquiries and speculations on the same subject since the existence of our constitution; and with them it has expanded into profound, laborious, and expensive researches into the figure of the earth, and the comparative length of the pendulum vibrating seconds in various latitudes, from the equator to the pole. These researches have resulted in the composition and publication of several works highly interesting to the cause of science. The experiments are yet in the process of performance. Some of them have recently been made on our own shores, within the walls of one of our own colleges, and partly by one of our own fellow-citizens. It would be honorable to our country if the sequel of the same experiments should be countenanced by the patronage of our government, as they have hitherto been by those of France and Great Britain." *The Addresses and Messages of the Presidents*, I: 591.

But waiting would not solve the pressing problems caused by poor standardization in the country. Facing inaction by the federal government, states took matter into their own hands, and one after another enacted legislations to fix standards and set controls for measuring instruments. However, states simply legalized the standards that were then in use in their own states, which only contributed in solidifying their differences.[134]

The area in which the federal government showed resolution and effectiveness was in securing uniformity in coinage and, more importantly, in the administration of weights and measures for custom houses—something crucial for an efficient extraction of revenue. And this opened the door to find an institutional way to set a foundation for national uniformity. Repeated reports in Congress indicated that there were considerable losses in revenue due to differences in the standards used in custom houses, and it was estimated that this loss in income in one week "would more than compensate the expense of establishing uniform standards."[135]

Some concrete actions were taken. First, in 1828, with John Quincy Adams as president, the "Act to continue the mint at the City of Philadelphia" set a standard troy pound—acquired from London—for the Mint of the United States, which virtually became the fundamental standard of mass for the country. Second, the Secretary of the Treasury delegated Ferdinand Rudolph Hassler (a Swizz scientists who in 1793 studied in

[134] Smith, *The Federal Basis for Weights and Measures*, 7.

[135] Jones, "Weights and Measures in Congress," 25. See also Register of Debates in Congress: Comprising the Leading debates and Incidents of the Second Session of the Eighteenth Congress, volume II (Washington: Gales and Seaton, 1826), 2648-2654.

Paris with some of the inventors of the metric system, like Lalande, Borda, Delambre, and Lavoisier) to construct proper and uniform standards of weights and measures for the customs service. And finally, in 1836 a Measures Act was passed, which mandated the delivery of a complete set of weights and measures to the governor of each state in the union,[136] "to the end that a uniform standard of weights and measures may be established throughout the United States."[137]

This marked the beginning of some national uniformity. However, the Measures Act of 1836 did not amount to a detailed plan, and many important issues about the administration and control of weights and measures were left unresolved. What legal requirements and specifications would regulate the day-to-day administration of weights and measures in the whole country? What methods of testing and inspection should prevail? Who has the authority to settle disputes between states? To whom should state inspectors of weights and measures report? There were no common frameworks or legal uniformity to solve these problems. If used properly, physical standards would only secure some homogenization—which was badly needed, of course. But not even that was fully achieved. As it turned out, the standards sent to the states by the federal government were in many cases neglected and some disappeared. Others were stored carefully but

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[136] *Report of the Secretary of the Treasury of the Construction and Distribution of Weights and Measures* (Washington: A. O. P. Nicholson, 1857).

[137] Jones, "Weights and Measures in Congress," 32; Smith, *The Federal Basis for Weights and Measures,* 8-10.

were never used to adjust the measures used within their respective states.[138] For metrological matters, *E pluribus unum*—"Out of many, one"—was simply not happening; there was rather, out of one county, many sovereignties.

What is more, the expanding nature of the republic was complicating things even further (an aspect so far neglected by historians). The variety of weights and measures already present in the thirteen colonies was increased with the purchase of the Louisiana Territory from France (1804), the expulsion of Spain from Florida (1819), the annexation of the Republic of Texas (1845), and the annexation of the Mexican territories of Alta California and New Mexico (1848). This added to the American metrological pool a wealth of measures of French, Spanish, and Mexican origin[139]—something that has had perdurable consequences, as even in today's *Texas Agriculture Code* the "Spanish *vara*" appears among the units for length and surface, and in Louisiana there is the "*arpent*," which is a the pre-metric French unit.[140]

Civil War, Reconstruction, and Central State Authority

If there was a propitious moment in the United States history for a full adoption of the metric system it was shortly after the Civil War, during the period known as the

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[138] S. W. Stratton, "Address to the Conference," *Weights and Measures: Thirteenth Annual Conference of Representatives from Various States held at the Bureau of Standards* (Washington: Government Printing Office, 1921), 13.

[139] See, as an illustration, "The Metric System," *Hudson Star,* December 5, 1927.

[140] *Texas Agriculture Code* (chapter 13, § 13.022); "Arpent in Louisiana," accessed February 24, 2010, http://www.sizes.com/units/arpent_louisiana.htm. For information about Spanish measures in California and New Mexico see, for example, J. N. Bowman, "Weights and Measures of Provincial California," *California Historical Society Quarterly* 30 (1951): 315-338; and John Baxter, "Measuring New Mexico's Irrigation Water: How Big is a Surco?," *New Mexico Historical Review* 75 (2000): 397-413.

Reconstruction era. And it almost happened. Under the lead of northern Republican legislators (particularly Congressman John A. Kasson, from Iowa, and Senator Charles Sumner, from Massachusetts), a plan was put in place to advance the metric cause. The newly created National Academy of Sciences was asked to evaluate the pertinence of adopting the system, and in July 1866—sixteen months after the end of the war—a metric legislation was passed in Congress and signed by president Andrew Johnson, recognizing the meter, the liter, and the kilogram as legal units of measurement in the country.

This was the Metric Act of 1866, also known as the Kasson Act, after John Kasson, chair of the House Committee on Coinage, Weights, and Measures. Kasson had worked in Lincoln's administration and was a politician who had accumulated extensive experience on international agreements in his career. His interest in metrication was very explicit, not only in his support for this legislation, but also in his participation as vice-president of the American Metrological Society during the 1870s (the society wasnot an openly pro-metric organization, but one where many of the most prominent supporters of metrication in America were members).

The other key player behind the Metric Act was Senator Charles Sumner, a well-known abolitionist, leader of the radical Republicans in the Senate during the Civil War and Reconstruction, and close confidante to Lincoln. After the war, Sumner was among those asking for the dismantlement of existing Southern governments, the reorganization of confederate states by Congress, and the allocation of homesteads for freedmen.[141] In

[141] Eric Foner, *A Short History of Reconstruction* (New York: Harper & Row, 1990), 134-5.

1866, he was the chair of a special committee to which all bills concerning the metric system should be referred. On July 27 of that year, Sumner asked the Senate to approve two bills and a joint resolution related to the metric system, which were each taken up and passed. The joint resolution enabled the Secretary of the Treasury to furnish to each State one set of metric standards of weights and measures; one bill authorized the use in post-offices of weights of the denomination of grams; and the second bill, entitled the Metric Act of 1866, stipulated that "It shall be lawful throughout the United States of America to employ the weights and measures of the metric system; and no contract or dealing, or pleading in any court, shall be deemed invalid or liable to objection because the weights or measures expressed or referred to therein are weights or measures of the metric system."[142] This legislation, in other words, made the metric system a legal system of measurement in the country, but not the exclusive system (this was a notorious difference with the majority of the legislations being introduced in other nations at the time, like in Mexico in 1857, where compulsion and exclusiveness were always mandated).

Sumner's speech in the Senate was a spirited praise of the metric system, exalting its "cosmopolitan character," much in the vein of other metric devotees at the time all over the world. As he put it,

[142] "An Act to Authorize the Use of the Metric System of Weights and Measures," in *The Statutes at Large, Treaties, and Proclamations of the United States of America from December 1865, to March 1867,* ed. George P. Sanger (Boston: Little, Brown, and Company, 1886), 339. For some reactions and polemics around this law, see "The Proposed Metric System," *Scientific American* 15 (July 21, 1866), 50; "Metric System of Weights and Measures," *Chicago Tribune,* May 25, 1866.

> There is something captivating in the idea of weights and measures common to all the civilized world, so that, in this at least, the confusion of Babel may be overcome. Kindred is that other idea of one money; and both are forerunners, perhaps, of the grander idea of one language for all the civilized world. Philosophy does not despair of this triumph at some distant day; but a common system of weights and measures and a common system of money are already within the sphere of actual legislation. The work has already begun; and it cannot cease until the great object is accomplished.
>
> […]
>
> The adoption of the metric system by the United States will go far to complete the circle by which this great improvement will be assured to mankind. Here is a new agent of civilization, to be felt in all the concerns of life, at home and abroad. It will be hardly less important than the Arabic numerals, by which the operations of arithmetic are rendered common to all nations. It will help undo the primeval confusion of which the Tower of Babel was the representative. [143]

Sumner's view of the metric system as an "agent of civilization" was in perfect alignment with the rhetoric employed by Mexican scientists (as I will show with in more detail in chapter four). But his proclaimed determination to keep with the work in favor of metrication "until the great object is accomplished" does not match well with legislation that did little more than making the metric system optional. He justified the softness of the law by saying that "The first step is taken there by making the metric system *permissive,* as is proposed in the bills before Congress. The example of Great Britain is of especial importance to us, since the commercial relations between the two

[143] Charles Sumner, "The Metric System of Weights and Measures," in *The Works of Charles Sumner* (Boston: Lee and Shepard, 1876), X: 525, 539.

countries render it essential that these should have a common system of weights and measures. On this point we cannot afford to differ from each other."[144]

The report of the Committee on Coinage, Weights, and Measures, headed by Kasson provided some other arguments for the non-mandatory nature of the law:

> The metric system is already used in some arts and trades in this country […]. Yet in some of the States, owing to the phraseology of their laws, it would be a direct violation of them to use it in the business transactions of the community. It is therefore very important to legalize its use, and give to the people, or that portion of them desiring it, the opportunity for its legal employment, while the knowledge of its characteristics will be thus diffused among men. Chambers of commerce, boards of trade, manufacturing associations, and other voluntary societies, and individuals, will be induced to consider and in their discretion to adopt its use. The interests of trade among a people so quick as ours to receive and adopt a useful novelty, will soon acquaint practical men with its convenience. When this is attained—a period, it is hoped, not distant—a further act of Congress can fix a date for its exclusive adoption as a legal system. At an earlier period it may be safely introduced into all public offices, and for government service.[145]

The reasons for the failure of the adoption of compulsory legislation can be attributed to the need to be in tune with England in terms of commercial standards, the wish to open the doors for the metric system to be used freely in all the states, the belief that Americans are particularly able "to receive and adopt a useful novelty," confidence that the metric system would be embraced voluntarily by the people, and the hope that

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[144] Sumner, "The Metric System," 539.

[145] "Report of the Committee on Coinage, Weights, and Measures," The Reports of the Committees of the House of Representatives, Made During the First Session Thirty-Ninth Congress, 1865-'66 (Washington: Government Printing Office, 1866), 20; see also The Metric System: A Compilation, Consisting of Extracts from the Report of the Committee of the House Of Representatives, and Law of Congress Adopting the System (Philadelphia: J.B. Lippincott & Co., 1867).

Congress would fix, in the not-too-distant future, a date for the exclusive use of the metric system—at least according to the main promoters of the Metric Act.

Little did they know that this was a wasted opportunity. No other moment in the United States history—at least for the next 150 years and counting—was as favorable for a comprehensive shift to the metric system. As it turned out, England was itself a century away from committing to the metric system (although even this eventual transition was not persuasive enough for the United States to make their own change, as we shall see below). In the end, Americans did not voluntarily adopt the metric system and Congress never set a deadline for a definitive switch to the metric units.

The timing for metrication, from the vantage point of international metrication, looked very appropriate in the 1860s. Contrary to the circumstances during Jefferson's and John Quincy Adams' times, the metric system had had a tangible worldwide impact. It had then become clear for many observers that if one system of measurement was going to grow into a truly "universal" system it would be the metric and no other. More and more countries were switching to the metric camp, with Europe and the Americas on their way to become mostly metric continents.

Moreover, the Reconstruction era was a perfect moment for metrication in America because it was inspired by principles and policies under which the metric system had thrived elsewhere: national unification, expansion of the administrative functions of the state, and economic modernization. For the first time in the history of the country, the federal government was in the position to consider and execute national-scale administrative undertakings, with the power of the states, especially in the South, being very limited. As Richard Franklin Bensel famously noted, "the American state emerged from the wreckage of the Civil War."[146] And this new state was penetrating into new areas of social life, like education, race relations, the labor system, and economic development.[147] It is not difficult to imagine an aggressive metrological policy in this context. But it never materialized. In the end, as Skocpol observed "even the Civil War did not generate an autonomous federal bureaucracy: the forces of localism, division of powers, and distrust of government activism never disappeared, even in the North."[148] And doubts about an activist state persisted among Republicans.[149] The kind of state needed to complete a national metrication program did not come to fruition in the United States.

While Congress legalized the use of the metric system, it never authorized programs to promote its general use.[150] Few instrumental actions were taken at all. Similar to what had happened in 1836, federal authorities were content with sending a set of metric standards to all states. The results, not surprisingly, were very poor. And the federal government did little during the rest of the century, at least domestically.

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[146] Richard Franklin Bensel, *Yankee Leviathan: The Origins of Central State Authority in America, 1859-1877* (New York: Cambridge University Press, 1990), ix; also on the history of the American state: Stephen Skowronek, *Building a New American State: the Expansion of National Administrative Capacities, 1877-1920* (New York: Cambridge University Press, 1982).

[147] Foner, *A Short History of Reconstruction*, 156.

[148] Skocpol, *Social Policy in the United States*, 21.

[149] Foner, *A Short History of Reconstruction*, 195.

[150] American Enterprise Institute for Public Policy Research, *Metric Conversion Bills* (Washington, American Enterprise Institute, 1974), 2.

Internationally, the United States was much more active in regard to metrication. In 1875, it signed in France, along with other sixteen nations, the Meter Convention (which created the General Conference on Weights and Measures, the International Bureau of Weights and Measures, and the International Committee for Weights and Measures).[151] The Senate ratified the Convention in 1878. Copies of the international kilogram and meter were distributed by lot among the signers of the Convention, and in 1890 the Unites States was awarded the kilograms number 4 and 20, and the meters 21 and 27. The standards were received in the White House by President Benjamin Harrison and later deposited in the Office of Weights and Measures of the US Coast and Geodetic Survey.[152]

With these standards at hand, Thomas Corwin Mendenhall, superintendent of Weights and Measures, issued an order (known as the "Mendenhall Order") that the international meter and kilogram would be regarded as the fundamental standards in the United States.[153] More than anything, this was just a technical issue. The Mendenhall Order indicated that the yard and the pound will be derived from the metric standards—which helped greatly to bring conformity between the federal standards and those of other countries—[154]but it did not stipulate any change for users, who could keep using customary units as usual.

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[151] On the works of the Bureau, see Chester Hall Page and Paul Vigoureux, eds. *The International Bureau of Weights and Measures 1875-1975* (Washington: National Bureau of Standards, 1975).

[152] Fischer, "History of the Standard Weights and Measures of the United States," 379.

[153] Judson, *Weights and Measures Standards of the United States*, 16-20.

[154] Smith, *The Federal Basis for Weights and Measures*, 17.

Overall, the federal government during the nineteenth century was negligent in providing an effective legal framework to secure uniform standards for the entire country and to secure an adequate provision of instruments and trained experts. The Coast and Geodetic Survey had the authority to make standards for the states, but did not have the power to issue certificates of verification. Besides, due to the lack of equipment and human resources, it could not verify all the instruments referred to the Office of Weights and Measures (the entire staff of the Office consisted of a field officer, two scientific assistants, an instrument maker, and a messenger), and measuring tools and standards had to be sent abroad for calibration, mainly to Germany.[155]

The most aggressive piece of legislation seriously considered in Congress came in 1899, with a law that proposed that the metric system would become the only legal system recognized in the United States, which received considerable support in the House of Representatives, but stiff opposition ultimately sank it. Congress was active during the first decades of the twentieth century, with around 50 bills related to the metric system proposed and debated, but nothing came of them. The battles around the 1899 law signaled the beginning of a very powerful anti-metric movement—formed by a coalition of engineers and manufacturers that effectively blocked any attempt for reform for the next 40 years (as we will see in the next chapter).

[155] A. Hunter Dupree, *Science in the Federal Government* (Baltimore: The Johns Hopkins University Press, 1986), 272.

In metrological matters, the United States was, to use Rexmond Cochrane's expression, a country of "laissez-faire standards;"[156] or perhaps more accurately, not a country but a loose association of states, a commonwealth. A compilation of state laws on weights and measures in the United States, dating from 1904, was almost 500-pages long, with fifty chapters—one per state—of non-homogeneous legislations.[157] It was an arrangement that was not providing adequate results at the national or local level. To illustrate, an observer in Brooklyn described this situation: "city surveyors recognized as legal four different 'feet': the United States foot, the Bushwick foot, the Williamsburg foot, and the foot of the 26th Ward. All legal, all different. Some stripes of Brooklyn real estate were untaxable, because, after two surveys, made with different units, these strips, legally, didn't exist!"[158]

To partially alleviate some of these difficulties, the National Bureau of Standards (NBS) was created in 1901 (today the National Institute of Standards and Technology), as the successor to the Office of Standards Weights and Measures of the Treasury Department.[159] The Bureau is responsible for a number of scientific and technological

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[156] Rexmond C. Cochrane, *Measures for Progress: A History of the National Bureau of Standards* (Washington: U. S. Dept. of Commerce, 1966), 33-38.

[157] National Bureau of Standards, *Laws Concerning the Weights and Measures of the United States* (Washington: Government Printing Office, 1904); National Bureau of Standards, *Laws Concerning the Weights and Measures of the United States* (Washington: Government Printing Office, 1904). For single state example see *Laws of the State of New York in Relation to Weights and Measures and Uniform Rules and Regulations* (Albany: J. B. Lyon Company, 1916).

[158] John Perry, *The Story of Standards* (New York: Funk & Wagnalls, 1955), 5.

[159] On the origin and functions of the Bureau, see Cochrane, *Measures for Progress*; P. G. Agnew, "The Work of the Bureau of Standards," *Annals of the American Academy of Political and Social Science* 82 (1919): 278-288; Louis Albert Fischer, "Recent Developments in Weights and Measures in the United

needs in the country, many beyond that of weights and measures. The NBS has custody of the national standards of weight and measure, tests the standards of the states, and supplies local officials with technical information and training, but it has no enforcement authority or regulatory abilities.

In 1905, the NBS hosted the first National Conference on Weights and Measures in Washington, a meeting of weights and measures officials at all levels of government and other people interested in metrology, which has met annually since then. The conference was convened with the hope of alleviating some of problems caused by the lack of uniform standards and regulatory oversight. Typical of what may be called the "American formula," the National Conference is an unofficial organization that has no legal status or authority to enforce its recommendations. To be effective, it banks on "its reputation among all who have any part in the distribution or control of commercial weighting and measuring devices."[160] The decisions of the Conference are then purely recommendatory, "a code of code specifications and tolerances […] or a model law that has been adopted by the Conference, can have no effect in any given jurisdiction until it is promulgated or enacted by competent authority within and for that jurisdiction."[161]

Considering the shaky legal ground on which the administration of weights and measures operates in the United States, this formula of non-mandatory coordination, led

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States," *Popular Science Monthly* 84 (1914): 345-369; Dupree, *Science in the Federal Government*, 271-277.

[160] Ralph Weir Smith, *Weights and Measures Administration* (Washington: National Bureau of Standards, 1962), 79. See also www.ncwm.net.

[161] Smith, *Weights and Measures Administration*, 82.

by the NBS, has worked reasonably well and has helped to set guidelines in the regulation of standards. The National Conference on Weights and Measures became a long-living body and has developed important model laws that have been widely accepted by the states. For example, the handbook *Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices* has been issued since 1949 and regularly updated, and all fifty states in the union have adopted it as the legal basis for regulating measuring tools. And as of 2002, forty-four states have adopted a weights and measures law based on the uniform laws delineated in an important handbook published by the Conference, *Uniform Laws and Regulations, in the Areas of Legal Metrology and Engine Fuel Quality*.[162]

If we go back to 1901, when the NBS was created in the United States, the metrological order of the country looked rather bleak. Standardization across the national territory was weak, with every state having its own weights and measures laws; there was poor policing to prevent short measures and cheating (with abundant frauds in markets and small transactions); the only federal office dedicated to weights and measures had very little power to verify the accuracy of standards (let alone keeping an eye on unfair commercial practices); and standards and instruments had to be send abroad to determine their accuracy. In short, by the beginning of the twentieth century, the United States government did not have legislation, a bureaucratic apparatus, or the expertise to provide

[162] Joan Koening, "Uniformity in Weights and Measures Laws and Regulations," in *A Century of Excellence in Measurements, Standards,* and Technology, ed. David Lide (New York: CRC Press, 2002), 368-370.

the services and enforce the regulations necessary for a soon-to-be industrialized economy.

Mexico, by contrast, had everything in place by the 1901. The government had decided that metric would be the only sanctioned system; laws, codes, and procedures had been approved; the federal government founded a central agency—the Department of Weights and Measures—headed by a meticulous engineer with a team of bureaucrats, inspectors, and a laboratory of metrology; state verification offices; and, finally, a mandatory curriculum for teaching the metric system in all elementary schools in the country. By 1896 Mexico had launched the first effective metrication campaign at a national level. It established the system, the legislation, the experts, the instruments, the punishing apparatus, and the teaching programs. The whole structure was working—more or less effectively—by 1901. When the Mexican revolution started, in 1910, the penetration of the metric system into urban areas was near completion, and some advances had been achieved in rural areas. If we compare both countries at this point in time, it looks like a sometimes loosely enforced mandatory policy was more effective, than a consistent *laissez faire* approach.

Alone in the World

The United States failed to adopt the metric system in moments of massive social change (i.e. after the war of Independence and after the Civil War). But a series of developments from the outside during the second half of the twentieth century brought a great deal of pressure to complete metrication in the country. By 1950, as we saw in the previous chapter, almost every single country in the world had adopted the metric system, with the exception of the United Kingdom and its current and former colonies. The globe was split in two parts, one metric—constantly expanding—the other using different versions of the English system—contracting.

The non-metric block was confronted with the problems of increasing isolation and a lack of uniformity in their units of measurement. Due to their relative independent development, inches, pounds, pints, and other units were not identical in different English speaking countries. To fix this, an agreement was sought in 1959 for the United Kingdom, Australia, Canada, New Zealand, South Africa, and the United States to agree to a common yard and pound (called "international yard" and "international pound"), which were defined in metric terms (the yard as 0.9144 meter, and the pound as 0.453 592 37 kilogram). They failed, however, to agree in a common pint; and that's the reason why a pint of beer the United Kingdom (equal to 20 imperial fluid ounces or approximately 568 milliliters) is larger than the American pint (equal to 16 US fluid ounces or approximately 473 milliliters—and different from the US dry pint, of approximately 551 milliliters). International coordination made this agreement necessary. Among other things, the discrepancies between the inches used in the United Kingdom and the Unites States became a problem during the Second World War, when mechanics found that some parts of aircraft engines, built in both countries following identical blueprints, varied enough to be noninterchangeable.[163]

[163] "International Yard," accessed February 20, 2010, http://www.sizes.com/units/yard_international.htm.

It should be noted here that for all its reluctance to go metric as a nation, the United States did its share in spreading the meter around the world, not only by supporting the Meter Convention, but more directly as part of its proto-imperial practices. In 1906, the United States initiated the metrication of the Philippines (soon after acquiring it as a result of the Spanish-American war in 1898); and the same happened in Japan after War World II, where the metric system was introduced in 1951 under the United States occupation. This was a small contribution to international metrication, which was about to become a domestic issue again.

In 1965 the United Kingdom announced a 10-year plan to move to the metric system. This was followed suit by Ireland and South Africa in 1967, New Zealand and Australia in 1969, and Canada in 1970. The cocoon that had protected the United States from metrological international isolation started to dissolve. In response to these events a new push for adopting the metric system started in America.

In 1968 Congress passed the Metric Study Act, providing for a 3-year investigation to analyze the impact of increasing the use of the metric system in the United States. The study, conducted by the NBS was released in 1971, a 12-volume report titled *U. S. Metric Study Report,* and a separate volume summarizing the finding, presented as a report to Congress, *A Metric America: A Decision Whose Time Has Come*.[164] It was a comprehensive investigation that included dozens of public hearings

[164] National Bureau of Standards, *A Metric America: A Decision whose Time has Come* (Washington: National Bureau of Standards, 1971); National Bureau of Standards, *U. S. Metric Study Report* (Washington: Government Printing Office, 1971). The 12 volumes of the *U. S. Metric Study Report* were dedicated to International Standards; Federal Government: Civilian Agencies; Commercial Weights and

and surveys on international trade, business, industry, consumers, national security, and education; there was even a volume dedicated to the history of metric controversies in the United States.[165]

The study presented by the Secretary of Commerce recommended, among other things, that the United States should change to the metric system "deliberately and carefully," through a "coordinated national program," and that "Congress, after deciding on a plan for the nation, establish a target date ten years ahead, by which time the US will have become *predominantly, though not exclusively,* metric."[166]

In a paper read before the American Philosophical Society, Lewis M. Branscomb, director of the NBS and the main figure behind the *U. S. Metric Study Report,* pondered the options of how to accomplish this proposed transition to the metric system:

> we homed in on two alternatives. The first is *laissez faire,* a perfectly sound principle and indeed the one that should be recommended in the absence of contrary evidence. The Unites States follows no overall plan; everyone does their thing. We do not set a target date for being metric and government does nothing either to impede or to foster the change, but allows individuals and companies to make their own decision. That is of course what we are doing now. And we are seeing a steady, perceptible, not yet dramatic, acceleration in the introduction of metric language into the country. The second alternative is a planned program of metric conversion based on an overall national program with a target for becoming predominantly but not exclusively metric. Within this

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Measures; The Manufacturing Industry; Nonmanufacturing Business; Education; The Consumer; International Trade; Department of Defense; A History of the Metric System Controversy in the United States; Engineering Standards; and Testimony of Nationally Representative Groups.

[165] Charles F. Treat, *A History of the Metric System Controversy in the United States* (Washington, DC: National Bureau of Standards, 1971).

[166] *A Metric America*, iii. Emphasis added.

framework, segments of the society would work out their own timetables and programs, dovetailing them with timetables of other segments. Such a plan would involve voluntary conversion; voluntary in the sense that it is not driven by any legislative or mandatory requirement, involuntary of course to the extent that if a consensus of the country decides to go that way then the commercial pressures to participate will be great for the minority of those who choose not; but it would become inconvenient for them.[167]

Despite more than one hundred years of experience indicating that voluntary metrication is almost equal to no metrication at all, the option of a "legislative or mandatory requirement" was not even considered. And this was the framework in which discussions in Congress took place in the following years.

Congress passed, in 1974, Public Law 93-380, "the Education Amendments," which included a section (403) stating, "It is the policy of the United States to encourage educational agencies and institutions to prepare students to use the metric system of measurement with ease and facility as a part of the regular education program."[168] The law was not a mandate, but a recommendation—and it came about more a century after Mexico had initiated its program of obligatory metric education in 1861.

The next year Congress passed the Metric Conversion Act of 1975, which declared that "the policy of the United States shall be to coordinate and plan the increasing use of the metric system in the United States and to establish a United States Metric Board to coordinate the voluntary conversion to the metric system." The Board was composed by representatives from scientific, technical, and educational institutions,

[167] Lewis M. Branscomb, "The Metric System in the United States," *Proceedings of the American Philosophical Society* 116 (1972), 295.

[168] Judson, *Weights and Measures Standards of the United States*, 26.

and state and local governments. The Act also required that each Federal agency "use the metric system of measurement in its procurements, grants, and other business-related activities, except to the extent that such use is impractical or is likely to cause significant inefficiencies or loss of markets to United States firms, such as when foreign competitors are producing competing products in non-metric units." And finally, the Act specified that it is the declared policy of the United States "to designate the metric system of measurement as the preferred system of weights and measures for United States trade and commerce," but also "to permit the continued use of traditional systems of weights and measures in non-business activities."[169] The federal government had reduced its role to the coordination of a voluntary transition plan and as an exemplar to the states by transitioning its agencies to the metric system.

As had happened throughout the century, a coalition of scientists, educators, and government officials supported the idea of going metric. Against it were industrialists (like the Automobile Manufacturers Association and the American Iron and Steel Institute) and labor organizations (like the International Brotherhood of Electrical Workers and the United Brotherhood of Carpenters and Jointers of America).[170] The industrial sector feared carrying the burden of paying for retooling and retraining; labor believed that the switch would make many workers obsolete, particularly older ones.

[169] "Title 15 U.S.C. Chapter 6 §(204) 205a - 205l Metric Conversion Law (Pub. L. 94-168, §2, Metric Conversion Act, Dec. 23, 1975)," http://ts.nist.gov/weightsandmeasures/metric/pub814.cfm, accessed December 18, 2009.

[170] Constance Holden, "Metrication: Craft Unions Seek to Block Conversion Bill," *Science* 184 (1974): 48-50, 94; Grace Ellen Watkins, "Measures of Change: A Constructionist Analysis of Metrication in the United States" (PhD diss., Southern Illinois University, 1998), 190-288; Malcolm Browne, "Kinder, Gentler Push for Metric Inches Along," *New York Times*, June 4, 1996.

Congress's plan did not designate federal funds to pay for those costs. As the *Metric Study* indicated in its recommendations, "in order to encourage efficiency and minimize the overall costs to society, the general rule should be that any changeover costs shall 'lie where they fall.' "[171] No mandatory dictate, a loose time table, and no budget to help pay for the costs. No carrot and no stick. Failure, as in 1866, was predictable.

The entire situation was not encouraging for the metric hopefuls. Those groups who wanted or needed to use metric measures (like scientists and exporters) were already using it. Those who did not want to switch faced no obligation and had no incentives to change. And among the general public indifference and skepticism towards the whole metric business prevailed.

The toothless Metric Board could not do much—and the arrival of the Reagan administration sealed its fate. In 1982 the Republican President sent a letter to the chairman of the board assuring his support for the policy of voluntary metrication and asking for cooperation in the "orderly phaseout of the Board's activities as part of my program to reduce government spending and streamline its operations."[172] In the end, the government did not force the change, did not pay for it, and ultimately did not coordinate a voluntary transition. 15 years of research and legislative work were wasted, and the United State secured its metrological isolation.

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[171] *A Metric America*, iii.

[172] Ronald Reagan to Louis Polk, March 9, 1982. A copy of the letter can be seen at http://lamar.colostate.edu/~hillger/laws/usmb.html, accessed April 12, 2010.

The only thing left for the federal government to try was to metricate the federal government itself. This goal has not been abandoned, and further legislation has ratified it, like the Executive order 12770, issued in 1991 by president George H.W. Bush, which ratified the directive, already present in the Metric Conversion Act, for the Secretary of Commerce "to direct and coordinate efforts by Federal departments and agencies to implement Government metric usage." But the results in this area have been unimpressive. And as Gerry Iannelli, director of the United States Metric Program (part of the National Institute of Standards and Technology) indicated in 1999, the government ran the "danger of building a metric island in the government, in a nation that is a nonmetric island, if you will, in a metric world."[173] Evaluations of how the metrication process of the government has developed show that such a scenario is more than a potential danger.

According to an study in 1994 by the US General Accounting Office, "since 1990, federal preparations for metric conversion have advanced dramatically, with more than 30 agencies having developed some combination of guidelines, transition plans, and progress reports that indicate a substantially greater commitment to metrication. However, they are still facing serious difficulties in putting their plans into practice. These difficulties include a procurement environment in which most products are nonmetric and in which federal agencies represent too small a share of the total market to

[173] Jason Zengerle, "Waits and Measures," *Mother Jones* 24 (1999): 70.

stimulate private sector conversion."[174] The report indicate also that government agencies cite private sector and public resistance to metric conversion as the reason for their slow progress; and that "the federal government must have the support of the private sector and the public for successful conversion to the metric system." An interesting pronouncement—and illustrative of the peculiar path that the United States has taken to achieve metrication. While in most countries, the state has helped or obliged the private sector and the public to go metric, in the United States, the federal government needs asks for the help of the private sector to metricate the government.

To finish this account of the tribulations of the United States federal government to control and administer weights and measures, I want to stress some of the structural issues that blocked its transition to the metric system: failure to centralize and aversion to compulsion.

Failure to Centralize

Two of the main issues that impeded American's full adoption of the metric system—namely the absence of central government control on weights and measures, and lack compulsory use of a sole measurement system—were never a serious issue in other places. In Mexico there were controversies about what system of measurement would be more appropriate for the country, and there was a silent—but palpable—resistance by the people to start using the metric units; but everyone involved in high-level metrological

[174] US General Accounting Office, *Metric Conversion: Future Progress Depends Upon Private Sector and Public Support* (Washington, DC: Government Printing Office, 1994).

discussions took for granted that it was the federal government's job to be in charge of unifying the measures nationally and that the employment of official measures had to be obligatory, not optional. But things were very different in the United States.

One of the touchiest questions in the metric debate in America was to determine what the locus of metrological authority should be. Should it be Washington, the states, or cities and counties? It was agreed that the federal government should hold and protect the national standards, but not that it should enforce, define, or police metrological conventions and practices. This opened the door for some interesting dynamics.

Metric proponents, for instance, tried to find ways to use state governments as leverage to push the metric system. An article in *The Banker and Tradesman* in 1877 argued, for example, that "until the US government adopts the metric system, it cannot permanently take root in the country. Let the authorities at Washington make but one trial of it in any one department and we feel sure that it would speedily be adopted by every department. Let our State legislatures take action in the matter, and let every private individual, either in conjunction with the bureau or of his own independent action, seek to make known among the masses the benefits to be derived from the adoption of a system already in use among a majority of the civilized and Christian world."[175] Bus this domino effect never even started among state governments.

The idea of using state governments to break down the opposition to the metric system by manufacturers and engineers was explored by people like Samuel Stratton, the

[175] "The Metric System," *The Banker and Tradesman,* September 26, 1877.

first director National Bureau of Standards, who he 1902 wrote to one of the leaders in a pro-metric organization saying that "if any legislation is enacted concerning the use of the metric system by the public, it will probably be the states, and then only with reference to the common weights and measures as used in every-day business transactions."[176] But, yet again, states never passed any compulsory metric legislation.

In the long run, lack of centralization served better the interests of people hostile to metrication. That is why they systematically opposed reforms that would increase the power of federal agencies, particularly the National Bureau of Standards. For example, in 1922 members of the American Institute of Weights and Measures forcefully challenged legislation proposed by Albert Vestal—Chairman of the Committee on Coinage, Weights and Measures—that would allow the NBS to approve all types of weighing and measuring devices used in the country, and to enforce its exclusive use. The concentration of authority in federal hands was welcomed by people like A. W. Epright, Supervisor of Scales & Weighing of the Pennsylvania Railroad System, who argued that "Our people [...] in general way, are inclined to favor the Bill inasmuch as we have had considerable inconvenience and expense as a result of various states through which we operate formulating laws of different kinds with regard to scale construction. As an instance, would a state like New York passed certain laws pertaining to the design and construction of scales, which will not permit us to use our standard scale in that State but

[176] Samuel Stratton to Melvil Dewey, December 13, 1902, CU, Melvil Dewey Papers, box 66.

which is acceptable in New Jersey, right across the River."[177] But the enemies of the bill banked on the states being "very jealous of their rights" [178] to defeat the motion in Congress—as they ultimately did.

With steady antagonism versus centralizing metrological regulation and states reluctant to do the change by themselves—due to the expense and considerable risk that going metric along would bring—the chances to find effective leadership in the government to guide the transition to the metric system never occurred.

Aversion to Compulsion

Some historians have pointed out that one of the main reasons for the "erratic course of adoption of decimal weights and measures" in the United States is "an American aversion to compulsion."[179] Indeed, the issue of forcing people to employ one, and only one, system of measurement—the one chosen by the government—has, on the one hand, fueled and galvanized metric opposition for more than a century; and, on the other, state officials and metric promoters have failed to provide a convincing explanation of why the metric system (or any other system, for that matter) ought to be exclusive and compulsory.

Of course the whole issue of compulsion, uniformity, and state intervention is prevalent in American history and it is present in numerous public debates. In public

[177] A. W. Epright to Samuel Dale, June 19, 1924, CU, Samuel S. Dale Papers, box 2.

[178] See Samuel Dale to George M. Bond, December 12, 1922, CU, Samuel S. Dale Papers, box 2.

[179] Gregory Higby and Glenn Sonnedecker, "Adoption of the Metric System by the US Pharmacopoeia," *Journal of the History of Medicine and Allied Sciences* 40 (1985): 207.

health, for example, officials lack the legal instruments to secure that parents will vaccinate their children, something that raise concerns when a considerable numbers of parents decide not to do so and make the whole population vulnerable to preventable diseases. But studies show that a majority think that "Parents, not the government, should make decisions about immunizing their children."[180] Equally, up to day it is been impossible to secure uniform education standards across the country, with states and cities defending fiercely their autonomy to control school contents; as an editorial in *The New York Times* recently lamented, "The countries that have left the United States behind in math and science education have one thing in common: they offer the same high education standards—often the same curriculum—from one end of the nation to the other. The United States relies on a generally mediocre patchwork of standards that vary, not just from state to state, but often from district to district."[181] If we substitute the word "education" for "measurement" in this quote, it may pass as a carbon copy from the metric debates in nineteenth-century America—a battle that was convincingly won by the "libertarian" camp.

This issue appeared very early in the metrological struggles. As Thomas Jefferson said to John Quincy Adams in 1817, "On the subject of weights and measures, you will have, at its threshold, to encounter the question on which Solon and Lycurgus acted differently. Shall we mould our citizens to the law, or the law to our citizens? And in

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[180] Hank, Jenkins-Smith, Carol Silva, and Geoboo Song, *Health Policy Survey 2010: A National Survey on Public Perceptions of Vaccination Risks and Policy Preferences* (Norman, OK: University of Oklahoma, 2010), 5-7.

[181] "National School Standards, at Last," *New York Times*, March 13, 2010.

solving this question their peculiar character is an element not to be neglected."[182] This question, which would be unthinkable in Mexico or France—were state officials were very clear that they should mould their citizens to the law—has torn apart the metric policy makers in America. Ultimately those who think that they should mould the law to their citizens have prevailed.

The question of compulsion was then one of the most poignant issues in the metric debate in America. Many opponents of the metric system were not strictly anti-metric, but rather adversaries of the compulsory introduction of any system. For many of them the metric was an adequate and useful system, but they did not want to be forced to use it, neither to set aside their ounces and yards. They liked to use one system or the other depending on the circumstances. As Frederick R. Hutton, member Society for the Promotion of Engineering Education, said in 1902 to a metric proponent: "most of us very much prefer the present condition of affairs where anyone who wants to use the metric system is at liberty to do so because it is legal and standard. We do not want, however, to see the use of it made compulsory on anybody to whom such use will be inconvenient, costly, and unpopular."[183]

The question of why should the government made the use of the metric system mandatory if it was already legal and could be used by whoever wishes to it has been particularly delicate for the pro-metric camp. And they never delivered a convincing

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[182] Thomas Jefferson to John Quincy Adams, November 1, 1817, in *The Writings of Thomas Jefferson*, ed. H. A. Washington (Washington: Taylor & Maury, 1854), VII: 87.

[183] Frederick R. Hutton to Melvil Dewey, December 9, 1902. CU, Melvil Dewey Papers, box 66.

answer to shape public debate. They have known that compulsion is essential to achieve full metrication; but emphasizing a policy of state-lead imposition would be a questionable political strategy. The “repulsion to compulsion” latent in American political culture weigh heavily against the metric hopefuls.

Obviously this was an unpleasant and delicate topic; imposition does not play well with democracy and political freedom. Then, one of the main shortcomings for government agents and others interested in advancing the metric cause it has been their deficiency to articulate the necessity for a mandatory policy within a democratic regime—a lack of creativity in their political philosophy, so to speak. So, even if it was one of the crucial elements for metric legislation, metric enthusiasts usually avoid completely the topic of obligatory use of the system. They always presented strong arguments about the international character of the metric system and about the benefits its adoption would bring to American exports, science, and education. But when presented with the question of why to make the metric system obligatory (or as an anti-metric observer put it “If metric is so superior, why can’t it win on its own, without compulsion?”[184]), pro-metric spokesmen usually tumbled.

The lack of articulation that hunted supporters of metrication made them present odd arguments like this by Edward Wigglesworth, member of the American Metric Bureau:

[184] Guy M. Wilson, Review of *The Metric System of Weights and Measures,* by National Council of Teachers of Mathematics, *The Journal of Educational Research* 43 (1949): 75.

> We need a benevolent despot who would *compel* the use of the Metric System here after a fixed day. After a week no one would have any more trouble; after a month people would wonder how they could ever have used anything else, the labor of learning is so slight, the gain immense. All the poor peasants of Europe, the lowest classes of "effete despotisms," etc., etc., have been able to adopt it *at once,* and yet Americans, self-ruling, are really too lazy, while merely claiming to be so stupid so to do. Shame on a country which "to party gives up what was meant for mankind."[185]

Needless to say that this was a losing strategy in a rhetorical battle. Members of the anti-metric movement were more effective in building a vocabulary to emphasize the "anti-democratic" character of compulsory metrication. Take for instance Samuel S. Dale, member of the American Institute of Weights and Measures, and one of the most active and prolific defenders of customary measures in the United States during the first half of the twentieth century. In his correspondence to recruit politicians and public official to his movement, Dale usually linked the metric system to its origins, to underline that the bloody French Revolution, regarding metrication, was "the inauguration of compulsion on a gigantic scale,"[186] it was the origin of "a decimal despotism imposed by the compulsory use of the metric system."[187] Or as he detailed elsewhere,

> the experience of France has demonstrated beyond question that a people's established weights and measures cannot be changed by the power of law. The most drastic of compulsory law for 110 years in France has resulted only in confusion, because the success attained has been incomplete. Drastic laws like those in France can compel government employees and to a certain extent, merchants in the market place to use

[185] *Medical Group Circular of the Metric Bureau*. Boston: American Metric Bureau, 1878.

[186] Samuel Dale to James B. Gardner, March 21, 1923, CU, Samuel S. Dale Papers, box 4.

[187] Samuel Dale to William C. French, September 6, 1923, CU, Samuel S. Dale Papers, box 4.

certain standards, but they are powerless to compel the workman and the manufacturer in the privacy of this own workshop or factory to obey the law by thinking and using governmental standards. The force of habit is here superior to law.[188]

By the same token, Frederick Halsey, who may be distinguished as the mayor public figure against the metric system in American history, declared in an article published in *The New York Times,* during Prohibition:

> The outstanding fact is that the people will not use the metric system unless compelled to do so, while even the most drastic compulsory laws have never succeeded in eradicating old units, this being true of France as of other countries. Whatever the reader's view of prohibition, our experience with it should convince all that laws that attempt to change the habits and customs of the people by creating crimes of acts that many do not consider wrong are difficult of enforcement. Fancy fining and even jailing a merchant or a grocer for selling dry good by the yard and butter by the pound—things they have done since the Pilgrim Fathers have done at Plymouth Rock! And yet that is the meaning of compulsory laws, and all history shows that nothing less will accomplish the purpose.[189]

Ideas like this were fairly regular in newspaper debates. As an anonymous contributor argued in a Wyoming daily, in response to some chambers of commerce, industrial organizations, and state legislatures which were "urging liberal metric legislation" to Congress:[190] "There will be a lobby, letters will be mailed to congressmen and Congress might be swayed into making the metric system the official system for the

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[188] Samuel Dale to John W. Gaines, December 22, 1903, CU, Samuel S. Dale Papers, box 4.

[189] Frederick Halsey, "Disputes Metric Success," *New York Times,* August 23, 1925; also of interest for this issue are Gertrude Cushing Yorke, "Three Studies on the Effect of Compulsory Metric Usage," *Journal of Educational Research* (1944): 343-351; Fred A. Geiger, "Why the Metric System Must Not be Made Compulsory," *Machinery* May (1920); and W. Le Conte Stevens, "The Metric System: Shall It Be Compulsory?," *The Popular Science Monthly* 64 (1904): 394-405.

[190] "Advocates the Adoption of Metric System," *San Francisco Chronicle,* Feb 13, 1927

country, but the people of the United States are likely to continue to measure distance by the mile, instead of the kilometer, and to buy milk by the quart and not by the liter for many a day to come. Habits break more laws than laws break habits."[191]

And the durability of this line of thought has been remarkable. Take for example, the present opinion of a thirty-five year-old engineer, who wanting to protect customary measures created a webpage—freedom2measure.org—and declared that

> unelected, unaccountable bureaucrats are trying to take your way of measuring away from you. […] Metrication is unnecessary and expensive. Worst of all compulsory metrication is undemocratic. Who ever asked you if you wanted the metric system? Our traditional, customary American weights and measures are units that we know and use easily. Miles, feet, gallons, quarts etc. are units that we are comfortable with. They are part of our heritage. Metrication will not only destroy part of our cultural inheritance, it will mean that a large percentage of Americans will be cut off from understanding measurement. The metric system is already creeping into the USA. Please help us stop compulsory metrication now![192]

But enough with these examples; suffice to say that since the metric legislation of 1866, opposition to the metric system in the public arena has centered its efforts in blocking any compulsory legislation. Pro-metric groups have not been able to articulate an adequate response to that position, and state officials have not showed much resolution to go for metric enforcement—resolution that they actually had with the monetary policy.

But besides the political aspects of the problem, the matter of why the introduction of the metric system has to be mandatory in order to be effective is a

[191] "The Metric System," *Tribune* (Cheyenne, Wyoming.), December 12, 1927.

[192] www.freedom2measure.org, accessed December 11, 2005.

legitimate sociological question. Why has voluntary adoption been so ineffective? A possible answer is that as any other language the metric system needs a whole community of speakers to exist at once. For a carpenter who adopts the metric system it is not enough to measure objects in meters and centimeters, she needs to communicate with suppliers, assistants, and clients, and if they do not understand metric units she will not be able to actually switch entirely to the metric system. Not to mention the intrinsic problems brought by the whole material landscape that she inherited which was completely organized and constructed on the basis of non-metric units, forcing people to think in non-metric terms.[193]

Something like that happened with the timid experiments carried out in the 1970s by the US Metric Board, when signs in some Arizona and Ohio highways were switched to metric.[194] This created confusion and displeasure among drivers, who were not skilled yet in using metric units and whose car's speedometers indicated miles per hour, not kilometers per hour, what made estimations of speed and distance very complicated.

In general, voluntarily adoption of the metric system has not worked because it punishes people willing to take the risk of making the change alone, while the rest of the material and social landscape is still working with the old measures. Merchants and industries that stepped forward and adopted the metric units voluntarily got isolated in the middle of a sea of users who did not understand metric measures.

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[193] For a brief but thoughtful reflection in this lines see A. J. Stubbs, "The Necessity of Compulsion," *Decimal Educator* 2 (1919): 155.

[194] "On a Highway in Arizona, the Mile Makes Way for Metric Stadnard," *The New York Times*, September 10, 1979.

This may help us explain why the adoption of the metric system has been always an *imposition from above;* never the metric system has been the system of measurement used by the people prior to the official adoption by the authorities. The meter has always replaced local forms of measurement, and that has produced social anxiety and agitation (and in some cases, contention and violence). Thus, the coercive abilities of the state have been central in the imposition of the new system of measurement. And because the change to the metric system in a country requires a sustained effort of various decades, the *unity* and *continuity* of state policies are crucial.

The importance of the state for metrological maters can be seen more clearly if one tries to answer the question "What is necessary to make the conversion from a system of measurement to another in a given territory?" Multiple national experiences of transitioning from pre-metric to metric measures have taught us that at least the following procedures are required: 1) to pass laws that prohibit the use of the old measures; 2) to have the ability to enforce those new laws; 3) to prevent, control, and repeal social and political reactions against the imposition of the new system; 4) to make the new system understandable for the people; 5) and to provide the technical, and scientific tools to make the metrological transition possible.

CHAPTER III

The Search for the Perfect Language for Commerce: Measurement and Economy Life

This chapter deals with the problem of how economic actors in the United States and Mexico, during the nineteenth and twentieth centuries, struggled to define what standards of weighs measures would benefit them the most. Two processes in particular are analyzed in depth. First, the interactions between the metric system and monetary policies which were interweaved with the issue of establishing a "universal currency." Second, the metric question in the United States is considered through the issue of Pan-American economic integration. But before that, I will go through some historical and theoretical considerations on the role of weights and measures in economic life.

1. ECONOMY AND MEASUREMENT: SOME THEORETICAL AND HISTORICAL CONSIDERATIONS

Weighing and measuring are one of the corner stones among the cognitive processes involved in economic activities. Setting shared standards of weights and measures is of special importance for economy—understood as a set of social relations. Systems of measurement—like the metric system—are economic instruments; they are a sort of "social knowledge" involved in production and exchange processes.[1]

[1] On the idea of social knowledge and economic production, see Karl Marx, *Grundrisse: Foundations of the Critique of Political Economy* (London: Penguin, 1993), 706.

Economic exchange requires measurement. When different products and commodities are sold or bartered it is necessary to know how much of a product is being bought or exchanged. Commodities are sold using measures of weight, length, and volume: bushels of grain, yards of linen, gallons of wine. The systems of measurement are particularly relevant for economic relations because multiple economic activities require the use of accepted social conventions about measurement, activities such as taxing (particularly in societies where taxes are paid in kind), and virtually all spheres of production also need effective measurement: the extension of a land to sustain a community, the amount of meat that can be sold in a week, the weight of wood that can be transported by a mule. As Douglass North puts it, "Underlying all exchange is measurement. Throughout history measurement has occupied the attention of human beings in their effort to improve the exchange process as well as in their effort to take advantage of each other in that process. The very terms price and quantity imply the ability to measure those two dimensions."[2] Systems of measurement are then—among other things—economic institutions.

At the same time, the genesis and development of the systems of measurement have to be related to particular economic relations. In the words of the anthropologist Thomas Crump, "Measurement of quantity is an operational use of number, whose function must be defined largely in economics terms. […] The institution of measurement

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[2] Douglass C. North, Review of *Measures and Men,* by Witold Kula. *The Journal of Economic History* 47 (1987): 593-594.

must have 'utility' before one may expect to find it in any given culture."[3] So, systems of measurement are developed and adopted within specific sets of economic relations. A system of measurement used by peasants in a self-sustained village in the middle ages would vary greatly from one used by merchants in a big commercial Renaissance city like Venice; their exactness, complexity, and level of standardization will diverge considerably because they satisfied different economic and social requirements.

To a greater or lesser extend—and with different degrees of success—systems of measurement adjust to the requirement of the economic and social systems to which they are related. Local, autarkic economies, centered in self-maintenance and with scarce economic exchange with one another, usually developed systems of measurement that are local too. Our contemporary global economy favored the development of globally accepted systems of measurement. It is impossible to argue that there is a perfect correlation between these two phenomena—there are, as I have indicated several times, other determinant factors to explain the global spread of moderns systems of measurement—but certainly there are numerous communalities and mutual influences. Large-scale capitalism contributed to the global expansion of the metric system—and the metric system facilitated the operations of the world market. There is a dialogical relation between economic life and measurement; they influence each other in their development, propitiating changes or inhibiting further developments.

[3] Thomas Crump, *The Anthropology of Numbers* (Cambridge: Cambridge University Press, 1992), 72.

Measurement, Transaction Costs, and Asymmetric Information

Douglass North has underlined the important relationship between the standardization of measures and economic transactions, or more specifically, to the issue of transaction costs (the costs "of specifying and enforcing the contracts that underline all exchange"[4]), the problem of asymmetric information (i.e. "buyers and sellers [exchanging] goods on the basis of different amounts of information about costly-to-measure attributes of goods or services"[5]), and measurement.

An important part in reducing transaction costs is the accurate specification of what is being exchanged. A crucial factor in this process is the cost of measuring the attributes of goods and commodities that are traded. When weights and measures are intricate and incompletely standardized those costs are higher—diversity of weights and measures makes the search for information laborious, uncertain, complex, and irregular. Conversely, according to North, the development of uniform weights and measures reduces the costs of measurement.[6] Likewise, establishing standardized weights and measures not only in local and abroad markets helps negotiation and enforcement on long-distance commerce. In this regard metrological regularization is an instrument that aids economic processes in a similar vein as it is done by the development of units of

[4] Douglass C. North, "Transaction Costs in History," *The Journal of European Economic History* 14 (1985): 558.

[5] Douglass C. North, Review of *Measures and Men,* by Witold Kula. *The Journal of Economic History* 47 (1987): 594.

[6] North, "Transaction Costs in History," 560-566. For an particular historical example of this process see Masaru Iwahashi, "The Institutional Framework of the Tokugawa Economy," in *Emergence of Economic Society in Japan, 1600-1859,* ed. A. Hayami, O. Saito, and R. P. Toby (New York: Oxford University Press, 2004), 96-98.

account, mediums of exchange, merchant law courts, notaries, and enclaves of foreign merchants—all of them lower information costs and provide incentives for contract fulfillment.[7]

Clear and understandable units and methods of measurement are then needed for the development of markets. As Peter Swann explains:

> improvements in measurement can help to reduce the transaction costs between suppliers and customers in a market economy. One of the most common sources of market failure is asymmetric information between buyers and sellers, where the buyer cannot distinguish good products from bad and therefore does not buy. Often this arises because measurement is difficult or expensive. As measurement improves and becomes cheaper, then buyers can measure any product characteristics they wish to, and that eliminates the asymmetric information and reduces the transaction costs. Indeed, many producers use measurements of product characteristics to advertise their products. Moreover, the danger of asymmetric information is not just that there will be market failure. Another possibility is that buyers will underestimate the risk of purchasing a bad product and will buy when they should not do so.[8]

If we cross this principles with what was said in the previous chapter about states and measurement, it is easy to see how many times the intervention of the political authorities provides the conditions for good information in the market[9]—even if some times that intervention benefits some actors more than others.

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[7] Douglass C. North, "Institutions," *The Journal of Economic Perspectives* 5 (1991): 100.

[8] Peter Swann, "The Economics of Metrology and Measurement," Report for National Measurement Office, Department for Business, Innovation and Skills (2009): iv (see also 60-64).

[9] Bruce Carruthers and Sarah Babb, *Economy/Society: Markets, Meanings, and Social Structure* (Thousand Oaks: Pine Forge Press, 2000), 7.

Economic Rationalization and Measurement[10]

Another important area for the sociological understanding of measures in economic life is related to the Weberian problem of rationalization. As it is well known, the concept of rationalization means for Weber that social action is disciplined, systematic, rigorous, and methodical. In this sense, rationalization implies areas of social life that are directed by regularity, calculability, and coherence. In Weber's analysis of modernity, rationalization has permeated different spheres of social life in Western societies: religion, law, science, art, philosophy, politics, economy, etcetera.

In Weber's words, "a system of economic activity will be called 'formally' rational according to the degree in which the provision for needs—which is essential to every rational economy—is capable of being expressed in *numerical, calculable terms,* and is so expressed."[11] The main aspect of rationalization in economy, from this perspective, is *calculability:* money, technology, free labor, capital accounting, and double entry bookkeeping are social practices and institutions that helped the development of rational capitalism. In this context, Weber was particularly interested in what he called "the sociological consequences of money." For him the most significant of those consequences was precisely the *possibility of calculation.* Money renders possible the assignment of numerical values to goods and services involved in economic

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[10] A modified version of this section was first published in *Max Weber Matters: Interweaving Past and Present,* ed. David Chalcraft *et al.* (London: Ashgate, 2008), 135-147.

[11] Max Weber, *Economy and Society* (Berkeley: University of California Press, 1978), 85. Emphasis added.

exchanges. In Weber words, who followed closely Simmel in this point, "everywhere it has been money which was the propagator of calculation."[12]

Calculation is key for economic rationalization, and it has to be based on quantitative and impersonal systems. Here lays the importance of using numerical terms which are unambiguously and "without a wholly subjective valuation" for economic activities.[13] Market itself is based in these numerical and impersonal characteristics. For Weber, a market situation is confined to the exchange of money because money allows "uniform numerical statements" about social relations. At the same time, instead of evaluating goods exclusively in terms of their importance for the present moment, monetary calculation makes possible the systematic comparison of future opportunities of utilization of those goods.[14]

However calculation of economic activities in precapitalist economies went beyond monetary terms. Here the role of weights and measures is crucial. Weber clearly saw how weights and measures were important for the development of the routine of quantified calculation. Weber dedicated an entire subsection of his "categories of economic action" to *calculation in kind*.[15] And he observed that, for instance, bars of bullion that were weighed instead of coined, were treated as money i.e., they were used for payment and exchange. For him the fact that these bars "were weighed has been

[12] Weber, *Economy and Society,* 81, 107.

[13] Weber, *Economy and Society*, 101.

[14] Weber, *Economy and Society*, 81, 83.

[15] Weber, *Economy and Society*, 100-107.

enormously important for the development of the habit of economic calculation." As we can see, for Weber—as for Simmel—money was a central instrument for the expansion of calculation. But the argument can be made that in many ways weights and measures opened the way to that *habit of calculation.*

Max Weber stressed that economic rationality requires specific intellectual means and those means are socially constructed in particular societies and also that can be transmitted from one society to another. But these intellectual means are not a given of the human mind, they are historical creations. The case of Hindu-Arabic numerals and positional notation, which were introduced into Europe in the fifteenth century, is revealing, because without those systems of thinking it is difficult to imagine the sole emergence of capitalism.

Economic rationality—as we know it in modern times—is not universal; it is rather the product of particular developments of economic and cognitive relations. Discussions about knowledge and economy have to consider this large dimension of reasoning as a historically-shaped human capability. Economic systems need certain degree of accumulation of knowledge and certain collective abilities within the members of a society (e.g. literacy and numeracy); economic processes depend on that "economy of knowledge." As Sharon Zukin and Paul DiMaggio claim, that there is a cognitive embeddedness in economic phenomena. This kind of embeddedness refers to "the ways in which the structured regularities of mental processes limit the exercise of economic reasoning."[16] To be fully effective the definition of cognitive embeddedness has to be broaden, and underline that not only mental processes limit economic reasoning, but also that cognitive processes (which are socially shaped) make economic reasoning possible. As Jack Goody has shown, the historical development of different intellectual technologies made possible the very existence of large and complex economies. The invention of writing, for example, extended the possibilities of management, commerce and production "in transforming the methods of capital accumulation and in changing the nature of individual transactions of an economic kind."[17] And we should add to these examples the development of fixed, clear, and stable systems of weights and measures.

Weights, Measures and Money in Pre-capitalist Economy

As Witold Kula noticed, the functions of measures and money in pre-capitalist economies varied considerably from the functions they have today.[18] This can be seen in functions like the relation between money and measures in terms of prices, the way in which land was measured, and the problem of interests.

Money and Measures

Measurement, according of Douglas North, underlines all exchange and "throughout history measurement has occupied the attention of human beings in their

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[16] Sharon Zukin and Paul DiMaggio, *Structures of Capital: The Social Organization of the Economy* (New York: Cambridge University Press, 1990), 15-16.

[17] Jack Goody, *The Logic of Writing and the Organization of Society* (New York: Cambridge University Press, 1986), 46.

[18] Witold Kula, *Measures and Men* (Princeton: Princeton University Press, 1986).

effort to improve the exchange process [...]. The very terms price and quantity imply the ability to measure those two dimensions."[19] Money itself is a unit of measure and for centuries its *value* was determined by the *quantity* of precious metals it contained.

As a unit of account, money functions to transform qualitative differences into quantitative ones, and this quantitative expresion connotes objectivity to monetary valuation. Here again, this process needs a receptive audience able to understand and accept this kind of abstraction and with the intellectual skills to grasp it.[20] At this point the sociology of money gets connected with the issue of the social distribution of knowledge, specifically with the spread of numeracy (or quantitative literacy).

The historical relation between money and measures is useful to understand the evolution of the functions play by money.[21] In modern economy, as every contemporary consumer knows, the relation between the quantity of money and the quantity of a commodity is that the quantity of money is variable while the quantity of the commodity is fixed. For example, when the cost of gasoline changes, what varies is the price of a fixed quantity of gasoline; so a *gallon* of gasoline that today costs 4.39 dollars, six months later it may cost 4.69. Variable money for a fixed quantity of a commodity; we are very familiar with this formula.

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[19] Douglass North, Review of *Measures and Men* by Witold Kula. *The Journal of Economic History*, vol. 47, no. 2, Jun. 1987, pp. 593-594.

[20] Bruce G. Carruthers, "The Sociology of Money and Credit," in *The Handbook of Economic Sociology,* ed. N. Smelser and R. Swedberg (Princeton: Princeton University Press, 2005), 358.

[21] On some of these problems see Witold Kula, "Money and the Serfs in Eighteenth Century Poland," in *Peasants in History,* ed. E. J. Hobsbawm *et al.* (Calcutta: Sameeksha Trust, 1980), 30-41; and Witold Kula, *An Economic Theory of the Feudal System: Towards a Model of the Polish Economy, 1500-1800* (New York: Verso, 1976).

However, in pre-capitalist economies this relation was exactly the opposite: the quantity of the commodity was variable while the quantity of money was fixed. In this sense, prices were fixed and could not be altered. When the cost of a commodity raised or dropped what varied was the quantity of the commodity. The most common example of this was bread. The prices of bread in virtually all Europe (and in the European colonies in the Americas), up to the eighteenth century, did not change. Consider the case of New Spain, where the oscillations in the price of bread were regulated by modifying the weight of the loafs. The loaf always cost half a *real,* but the weight of the loaf could vary; so, the higher the price of wheat and flour, the smaller the loaf of bread. Sometimes half a *real* would buy an 18-ounces loaf, in some other occasion a 13-ounces loaf,[22] and the same happened with other basic products, like butter and cheese. In other words, *prices were expressed in the quantity of the commodity, not in the quantity of money.* In Kula's words, the price as a mechanism that reduces to a common denominator all factors in a given commercial operation is a relatively recent phenomenon.[23] In some ways, weights and measures were something like the "money of the past." Money actually became the *universal commodity equivalent,* as we know it today, only after the advent of capitalism; and even then the practice of adjusting prices through measure still exists in today's markets.

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[22] See the works of Virginia García Acosta, "Weights and Prices of Bread in Eighteenth-Century Mexico." *Cahiers de Métrologie* 11-12 (1993-1994): 45-57; and "Medidas de antiguo régimen: medidas con sentido social," in *Metros, leguas y mecates: Historia de los sistemas de medición en México,* ed. H. Vera and V. García Acosta (Mexico: CIESAS, 2011), 80-93.

[23] To see a more detailed description of the function of measures in pre-capitalist economy see Kula, *Measures and Men,* 102-110.

Sometimes, when the cost of goods increase, manufacturers decide to maintain the price of a product but they reduce its size, as a more discreet way to pass the rising costs on to consumers. This is a strategy known as "downsizing." Studies on consumer behavior have shown that "consumers are more sensitive to changes in price than to changes in quantity."[24]

Particularly in times of economic crisis, like in the United States after the 2008 recession, this practice is widely used. Organizations that monitor the prices and sizes of products, like Consumer Reports, noted that from 2008 on multiple companies downsized their products, while charging the same price. Multiple examples can be mentioned. Yogurt cups that went from 6 to 4 ounces (in the latter case with the product full of air bubbles to fill up the container); coffee cans that went from 11.3 to 10.3 ounces (with weight difference sometimes based on the amount of moisture removed from beans); paper towel rolls that went from 90 to 80 sheets per roll, etcetera.[25]

Measures of Land

Modern systems of measurement are based on an entirely *quantitative* conception of measure. However, old systems were not the same, because *qualities* were also considered in determining measures.

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[24] John Gourville and Jonathan J. Koehler, "Downsizing Price Increases: A Greater Sensitivity to Price than Quantity in Consumer Markets," Harvard Business School Working Paper, No. 04-042, 2004.

[25] "Downsized! More and More Products Lose Weight," *Consumer Reports Magazine*, February 2011, http://www.consumerreports.org/cro/magazine-archive/2011/february/home-garden/downsized-/downsized-products/index.htm, accessed May 15, 2011.

This qualitative element in measurement was present, for example, in the measurement of land. Today, all hectares are geometrically equal. A hectare is always 10,000 square meters, and acres are always 4,840 square yards, no matter if they are used to measure land that is in a desert or in a cornfield. On the contrary, pre-metric measures of land were not defined exclusively by geometrical standards, but also by their productivity (i.e., their quality). For example, one of the most common units to measure land in medieval Europe was determined by the "amount of seed." In some provinces of France, for example, the *setier* was a measure for dry products like corn and wheat (similar to the English bushel), but *setier* referred also to the necessary amount of land required to sow a *setier* of seed. Obviously, a *setier* of fertile soil was geometrically smaller than a *setier* of a less fertile soil. With this, "two plots of unequal area might thereby be 'equated', that is, shown to have virtually the same productive potential."[26]

Thus, one of the key features of modern methods of measurement is their abstract and quantitative character, embodied in the idea that reality can be grasped as a series of uniform units, like meters, liters, and grams (or seconds, power horses, watts, Fahrenheit degrees, etcetera).

Another category of land measure in pre-modern Europe was derived from the relation between *time* and *labour*, i.e., the "labor-time for plowing." In Spain and its colonies the *huebra* was defined as the land that a single person can plough in one day; and the *yugada* as the land that can be ploughed in one day using a pair of mules or oxen.

[26] Kula, *Measures and Men*, 31.

Here again, the geometrical extension was not the prevailing factor to measure land, "what mattered was the general emphasis on the relation of man to land."[27]

These practices of measurement survived until the origins of capitalism. In England, for example, the change occurred after Henry VIII expropriated the land of the Catholic Church and sold that huge amount of land. Also in the sixteenth century the enclosures of land started. These processes completely changed the practices that gave sense to the ancient systems of measurement. Once land was exchanged for cash, its quality, its relation with "labor-time for plowing," and its ability to support people became less important than how much rent it could produce.[28]

Interests and Measures in Pre-Capitalist Economies

In his *General Economic History,* Weber dedicated a brief chapter to the problem of interests in the pre-capitalist period.[29] Weber described the relatively novelty of the phenomenon of interest and how the religious prohibition of usury inhibited the practice of charging interests. In the Middle Ages this problem was partially solved with the practice of money lending by the Jews. It was allowed for Jews to lend money to Christians, since the prohibition was limited to the lending of interest money only among Christians.[30]

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[27] Kula, *Measures and Men*, 30.

[28] See Andro Linklater, *Measuring America* (New York: Walker and Company, 2002), 21-28. As we can see, it is not an accident that the changes in how land was measured coincided exactly in time and space with the "primitive accumulation of capital" described by Marx in *Capital.*

[29] Max Weber, *General Economic History* (London: Transaction Books, 1979), 267-271.

[30] Weber also noted that Protestantism broke up the prohibition against usury in the seventeenth century.

There were, however, some other ways to charge interests on a loan that involved the use of measures. Typically, measures of grain were very "irregular" (not standardized). These measures of capacity had actually three variations: heaped, striked, and shallow. Heaped meant that the measure contained grain above its rim; the striked measure did not exceed above the rim; and the shallow measure did not get to the rim.[31] This basically meant that the same measure could have three different magnitudes or amounts of grain.

A common trick for charging interests was lending grains in shallow measures and receiving the payment of them in heaped measures. In other words, "loans would be made and then repaid using different measures, the difference serving to conceal the element of interest."[32] Formally, there were not interests involved in this transaction, because it was paid the same number of measures that were lend, and thus the prohibition against interest was avoided. We can see here again that some economic functions—which involved detailed calculation—were practiced beyond money through the use of weights and measures.

Capitalism and Modern Systems of Measurement

Many of the economic settings in which pre-metric measures were used resemble what Clifford Geertz described as the "bazaar economy"—a market where information

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[31] Ronald E. Zupko, *Revolution in Measurement: Western European Weights and Measures since the Age of Science* (Philadelphia: American Philosophical Society, 1990), 20.

[32] Kula, *Measures and Men,* 109-110.

about the price and quality of the goods is poor, scarce, maldistributed, inefficiently communicated, and thus very valued, due in part because in the bazaar there is no product standardization (nor fixed standards of money and measures). It is a "system where little is packaged or regulated, everything is approximative, [and] the possibilities for bargaining along *non-monetary dimensions* are enormous."[33] Every aspect of the bazaar economy reflects the fact that the primary problem its participants face is not balancing options but finding out what those options are. In this context, practices like clientelization and bargaining, that may look as accidental customs for the foreigner, are actually procedures to search information.

It is also in an economic context like this that measures acquire their particular meanings and specific functions—usually part of communal, tacit understandings. Studying a local market in Haiti, Sidney Mintz makes this description of a unit of measurement for oils and underlines the subtleties and shared understandings that give robustness to measures in economic life:

> The principal measure for oils is the "little bottle" (*ti-poba*) or, more specifically, the "little polish" (*ti-glòs*). Filled to the neck, the *ti-glòs* holds 2.84 fluid ounces. It is a short, stubby square bottle of heavy white (or rarely, blue) glass with a wide round neck and thick lip. These bottles originally held a liquid shoe polish, whence the name; the polish is no longer sold in Haiti in such bottles, but the measure remains. It is convenient because it fits quite neatly with three important larger units, its contents are a popular selling quantity, its design and massiveness make it durable and readily filled and emptied, and its form is so distinctive that no other bottle would ever be mistaken for it.

[33] Clifford Geertz, "The Bazaar Economy: Information and Search in Peasant Marketing," *Supplement to the American Economic Review* 68 (1978): 29.

A customer buying any oil can tell immediately that the seller is using genuine "little polish," and thereby knows exactly how much he is getting.[34]

Mintz emphasizes that despite the different degrees of precision of the multiple measures used in this market, buyers and sellers know what they are getting and also have an informed comprehension of the relationship between quantity and price.[35]

Nevertheless, this homegrown way of setting units of measurement has serious limitations when commercial circuits get larger, which makes folk understandings too opaque for foreigners. And in this particular issue, the qualities of local knowledge are seen as a hindrance for both state formation and the long-distance trade.[36] As Theodore Porter underscores, converting units from one region to another required the intervention of experts in reckoning and it was a considerable hindrance for large-scale trade networks; not surprisingly, the development of capitalism (and nation-states) was an essential factor in the unification and simplification of measures.[37]

In a way, the tremendous utility of standardized and uniform weights and measures for economic life can be better appreciated when standardization does not exist. Take as example this statement by a chief trader in Madras, India:

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[34] Sidney W. Mintz, "Standards of Value and Units of Measure in the Fond-des-Nègres Market Place, Haiti," *The Journal of the Royal Anthropological Institute of Great Britain and Ireland* 91 (1961): 25.

[35] Mintz, "Standards of Value and Units of Measure," 23.

[36] One of the problems with local measures, for example, is the incommensurability between their units that renders economic calculations very complicated or impossible. For an illustration of this, based on anthropological in Panama in the 1960s, is Stephe Gudeman, *The Anthropology of Economy* (Oxford: Blackwell, 2001), 12-15.

[37] Theodore Porter, *Trust in Numbers* (Princeton: Princeton University Press, 1995), 25. See also Kula, *Measures and Men,* 114-119.

> I never can tell what I am buying nor how much I am selling. My agents inform me that rice is at so much the seer, while in another quarter it is double that price. I take advantage of the opportunity, invest largely, and expect great profit. When the transaction is closed, I find I have lost greatly. The seer in the first place was perhaps less than half the size of that in the other. No two villages have the same measures, and to ensure success, I should need an agent in every place, each with infinite opportunity for deception.[38]

A nice reminder that when system of measurement are defective or are not shared by all the parts comprised in an economic trade it became complicated to grasp accurately what and how much is being produced or exchanged. Problems like these tend to become even more prevalent when trade starts to involve people from more distance places. Up to a couple of centuries ago, when commerce was conducted across several countries or continents merchants need more and more time to figure out the names, magnitudes, and idiosyncrasies of measures used by local producers and by intermediaries. They need to worry not only about the quality of the products they acquired (there was little product standardization and the qualities of commodities used to vary great from year to year and from place to place) but also about how much they were buying. In eighteenth-century New York, for example, merchants complained frequently of the differences in measure and the imprecision of the terms used in contracts. One of them, who was ordering fifty barrels of rice from South Carolina to be sent to London, needed to make this remark: "By barrels I suppose is meant your half Tierces of about 4 bushels each. We have a variety of Wooden Vessels called in general barrel to that with us the Term has no

[38] Quoted in Debdas Banerjee, *Colonialism in Action* (New Delhi: Orient Longman Limited, 1999), 49-50.

determinate meaning without prefixing the name of the Commodity they are to contain and generally used for, as Flour, Pork, Bread etc. which are all different."[39]

Reacting to what already was a globally interconnected economy and to the volume of international trade, experts prepared manuals that provided information on weights, measures, and exchange rates between monies of different countries. The publication of these manuals, as Douglass North noted, represented a major development in history to reduce information costs.[40]

One of these manuals was Tomás Antonio de Marien y Arróspide's *Tratado general de monedas, pesas, medidas y cambios de todas las naciones reducidas a las que se usan en España* (General treaty on coins, weights, measures and exchanges of all nations compared with those used in Spain).[41]

For today's reader it would come as a surprise to learn that a manual like Marien y Arróspide's was conceived as a practical and time-saving device. Its fact-filled 600 pages with infinity of charts, equivalencies, and logarithms look rather cumbersome and perplexing. Its complexity, however, is just a pale reflection of the intricacies of thousands of local metrological conditions that traversed the world economy of the time. And despite its limitations, this treaty was a colossal accomplishment and indeed

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[39] Quoted in Virginia D. Harrington, *The New York Merchant in the Eve of the Revolution* (New York: Columbia, 1935), 79. A more detail analysis on this topic see John J. McCusker, "Weight and Measures in the Colonial Sugar Trade: The gallon and the Pound and their Equivalents," in *Essays in the Economic History of the Atlantic* (London: Routledge, 1997), 76-101.

[40] Douglass C. North, "Institutions," *The Journal of Economic Perspectives* 5 (1991), 106.

[41] Tomás Antonio de Marien y Arróspide, *Tratado general de monedas, pesas, medidas y cambios de todas las naciones reducidas a las que se usan en España* (Madrid: Imprenta de D. Benito Cano, 1789).

facilitated the toils of long-distance traders. But probably the most significant figure in this book packed with thousands of numbers is the one stamped in its cover indicating the year of publication, "MDCCLXXXIX"—1789, the year when the history of metrology changed forever, the year that started the revolution that made Marien y Arróspide's treaty obsolete with the invention of the decimal metric system.

Contrary to the variability, inexactness, and lack of standardization that characterized many of "pre-modern" measures, modern systems of measurement are fixed, exact, and have become globally standardized. The expansion of these systems and the development of monetary economy, made rarer—or even unnecessary—economic practices like those described by Geertz and Mintz. In this regard, capitalism and industrialization pave the way for the spread of more homogenous and transparent systems of measurement.

Since the creation of the metric system in the French revolution, the scientific and politic elites conceived it to be a universal language of the modern mechanisms of economic exchange. A single and rational system of measurement was an effective means to undermine the power of local authorities and local markets and to facilitate economic interconnectivity both among the different parts of a country and among countries.[42]

At the same time, the level of exactness achieved by the metric system and its highly quantitative character connected very well with a series of other developments in

[42] Ken Alder, "A Revolution to Measure: The Political Economy of the Metric System in France," in *The Values of Precision,* ed. N. Wise (Princeton: Princeton University Press, 1994), 39-71.

modern societies where objectivity and quantification were greatly appreciated. In the words of Bruce Carruthers "Quantitative measurement connotes objectivity and precision, and this aura encompasses monetary valuation as well. […] With quantitative information decisions appear less 'subjective' or 'arbitrary'."[43] Besides, quantification in economic processes helps to connect local transactions with larger circuits of exchange; quantitative measurement is facilitated by the immediacy of the market exchange.

Quantification and standardization in economy (embodied in institutions such as money and metrological unification) facilitate action at larger distances.[44] It was with the development of capitalism that a series of institutions started a process of standardization at the same time that they increased their presence in social life. Complementary to this process, "the social preconditions of large-scale capitalism involved the destruction of the obstacles to the free moment of economic transfer of […] goods."[45] It is partially in this context that we can understand better the standardization of currencies and measures, with the subsequent demolition of local and regional instruments in favor of national and international standards of value and measure—think for example in the "gold standard" used in the nineteenth and twentieth centuries for currencies and in the metric system, both spread throughout the world in the "era of capital," the second half of the nineteenth century.

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[43] Carruthers, "The Sociology of Money and Credit," 358.

[44] Bruce Curtis, "From the Moral Thermometer to Money: Metrological Reform in Pre-Confederation Canada," *Social Studies of Science* 28 (1998): 547-549.

[45] Randall Collins, "Weber's Last Theory of Capitalism: A Systematization," in *The Sociology of Economic Life,* ed. M. Granovetter and R. Swedberg (Cambridge: Westview Press, 2001), 384.

In this period, international initiatives (like the creation of the international standard time, the International Telegraph Union, the Universal Postal Union, and the International Meteorological Organization) were also developed. The metric system was part of this series of projects that helped to build international and interlinguistic mechanisms of standardization and coordination in a context when the world became increasingly unified.[46]

Under this light we can consider the metric system among several institutional supports for large-scale economic actions. The unification of measures facilitated the calculation of economic exchanges, and eliminated the considerable problems for international commerce that the multiplicity of measures produced. As we have seen, in the premetric era it was common that different measures were used by producers, intermediaries and consumers, which created considerable confusion and risk of frauds (it was common that customs brokers in ports with international commerce had to use tables with dozens of equivalencies with the measures of every country in order to determine the quantities of every commodity they received).

The international expansion of the metric system and the international expansion of capitalism occurred parallel and in a mutual reinforced fashion in the nineteenth and twentieth centuries. And also in this period virtually all countries witnessed a twofold process of unification of measures: on the one hand, the unification of measures within

[46] Eric Hobsbawm, *The Age of Capital, 1848-1875* (New York: Charles Scribner's Sons, 1975), 48-68; Akira Iriye, *Cultural Internationalism and World Order* (Baltimore: The Johns Hopkins University Press, 1997), 28.

every national-state; and, on the other hand, a growing international coordination that created a global system of measurement.

In a word, the development of capitalist economy was helped by more exact and rational systems of measurement that facilitated commercial activities, not just among different countries, but also among diverse regions within those countries. For Weber, one of the peculiarities of modern, rational capitalism is that it is methodical and predictable, "reducing all areas of production and distribution as much as possible to a routine."[47] The international standardization of measures was part of this process.

Of course, all this characterization of the relationship between capitalism and the rationalization of measurement needs a caveat. The fact that this process happened at large and in the long run does not mean that it was necessary, inevitable, unanimous, or even easy. Economic historian Sidney Pollard, for example, showed in his studies on eighteenth- and nineteenth-century England how thorny the process to standardize coal units of measure was, and how the intricacies of pre-modern definitions and techniques of measurement actually provided some useful flexibility within the context of capitalist calculation.[48]

Even more important is the word of warning that George Sarton left on the issue of "Why did the most industrial and mercantile nation in Europe reject the metric system, while its use would have caused great economies in time and money? Suppose the

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[47] Collins, "Weber's Last Theory of Capitalism," 381.

[48] Sidney Pollard, "Capitalsm and Rationality: A Study if Measurement in British Coal Mining, ca. 1750-1850," *Explorations in Economic History* 20 (1983): 110-129.

situation had been reversed, how tempting it would have been to explain the creation of the metric system as necessary result of the superior mercantilism of England."[49] Sarton's observation is not only a powerful reminder that we cannot equate the metric system with the expansion of the capitalism in a simplistic or mechanic way, but it posts a question of the most importance.

What follows will not address this question directly, but should shed light on why another of the most industrial and mercantile nations in the world—the United States—rejected the metric system, while its use would have caused great convince, and how that rejection happened in a context of close interaction and competition with Mexico (and Latin America in general).

2. AT THE CROSSROADS OF GLOBALIZATION: PESOS, DOLLARS, UNIVERSAL CURRENCY, AND METRIC MEASURES

Mexican Peso, 8 Reales or 100 cents?

The introduction of the metric system in Mexico was permanently tied to the currency reform. Metric laws throughout the nineteenth century were accompanied with legislation ordering the decimalization of currency—a change that essentially represented the elimination of the famous peso of eight reales (or piece-of-eight) that existed with that name and subdivisions since colonial times, and the introduction in its place of a peso of

[49] George Sarton, *The Study of the History of Mathematics* (Cambridge: Harvard University Press, 1936), 15.

100 cents. The coupling of these reforms was not a Mexican peculiarity, it was actually the norm for almost all countries (with only a few exceptions like the United States and Canada, where the transition to a decimal currency happened without a simultaneous change to a decimal measurement system). But for Mexico these changes brought an unexpected and acute predicament.

When confronted with the perspective of embracing the metric system mid-way through the nineteenth century, Mexico faced a dilemma regarding currency and weights and measures. On the one hand, opting in favor of metric measures and decimal money promised to link the country to what *appeared* to be the beginning of a global tendency that would help its incorporation into broader international markets. On the other hand, the metrological and monetary change would *certainly* jeopardize the solid position of the Mexican silver peso in the international market. Today we know that by the end of the nineteenth century gold had the upper hand on silver in the world market of precious metals and that the metric system was well established in Europe and Latin America; thus, based on what we know, an early adoption of the metric system was preferable in the long run. But that was far from obvious by 1850. Political and economic actors were forced to make decisions within the realm of possibles as they appeared to them. And at that point in time the option of not tampering with the existing monetary system looked completely reasonable.

Until late in the second half of the nineteenth century, the Mexican peso was a “universal money,” used in North America, Europe, and, more importantly, in Asia. Silver pesos minted in America became the most widely circulating currency in the world, which gave to the piece-of-eight its motto of "the first universal coin."[50] Large quantities of silver pesos made in New Spain and later in independent Mexico went to Europe across the Atlantic and were widely used in Spain, England, France, and the Low Counties. The wide circulation of Mexican silver pesos had also a visible effect in the economy of the British colonies in North America and throughout the first century of independent life of the United States. During the war of independence the government of the Confederation used the silver peso (the so called "Spanish dollar") as the metallic reserve for the new paper dollars. Since 1792 it was stipulated that the value of the United States silver dollar would be equated to the eight-real silver peso; and the Mexican silver peso was legal tender in the country all the way to mid-nineteenth-century.[51]

In addition, one third of the Mexican production of silver ended up in China, getting there either from the Atlantic (via European trade) or directly from the Pacific through the Manila-Acapulco galleons. It is estimated that from the late sixteenth to the early nineteenth century two million silver pesos arrived yearly to the Philippines from Mexico—the Philippines, named after the Spanish king, was governed by the Viceroyalty

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[50] For an overview of the global history of the Spanish dollar see Guillermo Céspedes del Castillo, "El real de a ocho, primera moneda universal," in *XIII Congreso Internacional de Numismática, Madrid, 2003: actas-proceedings-actes* (Madrid: Ministerio de Cultura, 2005), 1751-1760.

[51] Carlos Marichal, "The Spanish-American Silver Peso: Export Commodity and Global Money of the Ancien Regime, 1550-1800," in *From Silver to Cocaine: Latin American Commodity Chains and the Building of the World Economy, 1500-2000*, ed. Steven Topik et al. (Durham: Duke University Press, 2006), 46.

of New Spain and used its currency.[52] This was due in part to the fact that the rising production of Spanish-American silver never compromised its high quality. In China the silver Spanish dollars coined in Mexico had been highly regarded for their consistency in weight, shape, quality, and decoration. The piece-of-eight outlasted all forms of silver dollars in the late eighteen and nineteenth centuries in China.[53]

But when the Mexican government adopted the metric system and modified the design, subdivisions, and diameter its silver coins, China and other countries refused to keep accepting them, which represented a big blow to Mexican mining economy. Not surprisingly then, some of the critics of the introduction of the metric system in Mexico centered their arguments on this issue, as was the case of two prominent politicians and intellectuals, Lucas Alamán and Manuel Payno.

In the previous chapter I discussed Lucas Alamán's opposition to the metric system from the standpoint of the role of government, as presented in his 1849 article. In that text Alamán tackled this other crucial issue that reinforced his disagreement with the proposal to metricate Mexico. A man well-versed on economic matters, Alamán very quickly saw some of the drawbacks of metrication for the prospects of Mexico in the international market for silver and he opposed the legislation then before Congress that would have changed the weight, value, name, and divisions of Mexican currency.

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[52] Marichal, "The Spanish-American Silver Peso," 41-42; Miguel L. Muñoz, "The Mexican Peso in the Far East," in *Antología Numismática Mexicana,* (Mexico: M. L. Muñoz, 1977), 193.

[53] Man-houng Lin, *China Upside Down: Currency, Society, and Ideologies, 1808-1856* (Cambridge: Harvard University Press, 2006), 44.

In his arguments to keep the present currency, Alamán's article displayed a rare mixture of nationalist pride and economic pragmatism:

> The current currency and its divisions are entirely Mexican. Even more, it is the only thing in which Mexico has given laws to the whole universe. […] The use of this currency has been generalized and it is a glory for Mexico, since the foresight of the government was the origin of the better known form of money in the globe and the one with the broadest circulation. That would be a reason to keep it.[54]

Furthermore, Alamán argued that it was unwise to alter the most successful exporting commodity in the country for the sake of adopting a measuring system that was scarcely used in the world—we should remember that Alamán was writing just before the first big international expansion of the metric system, from 1849 to 1875 (see chapter 2 on this). From this point of view, Alamán reasoned that it was better to protect an already global institution that greatly benefited Mexico, rather than going with a system not so widely used and that offered no immediate advantages to the Mexican economy in the international arena:

> If all nations agree to adopt the French metric system—as they have done to stop the commerce of slaves—it would be our opinion that Mexico should do to what has been done everywhere, since any particular inconvenience would be justified by the general convenience—the great convenience of all the nations having the same weights, same measures, same currency, as it would be for them to have the same religion, same language, and same customs. […] Despite the great perfection of the French metric system no nation has adopted it, except for those that established it by using weapons. Besides, the number of nations that follow Mexico's monetary system is quite larger and

[54] Lucas Alamán, "Pesos y medidas," *El Universal*, March 22, 1849, 1.

> we should stick with the system that has the larger number of members. […] For the sake of finding uniformity with France we will break our links with Guatemala, all South America, the United States, Havana, Spain and its positions in Asia, the whole of Asia—where Mexican coins are preferred above others—and several European powers, countries all from which we receive fifty ships in our seaports for a single one that comes from France. [55]

Alamán did not live to see what happened with the metric system in Mexico. The 1849 proposal was unsuccessful, and he died four years prior to the official adoption of the system in 1857. It was another influential politician, economist, and intellectual, Manuel Payno, who years later saw in practice what Alamán feared as a mere hypothetical scenario.

Manuel Payno (1810-1894) was one of the better trained men in the country to tackle economic issues. Since very early age his father (an official in the administration of the colonial customs system, and, after independence, in the Treasury) acquainted him with the procedures of the economic administration of the country and obtained a post for him working in a customs house when Manuel was still a teenager. Payno ended up having a long and productive public career; in the 1850s he served twice as Minister of Finance, and later in his life as congressman and senator. He was also lecturer of political economy in the Escuela de Comercio (School of Commerce), and produced a number of

[55] Alamán, "Pesos y medidas," 1-2.

chronicles and novels (literary works that eventually cemented his long-lasting reputation).[56]

Early in his career Payno counted himself among some of the first supporters of metrication in Mexico by adding his name to a list of "professionals, merchants, and persons with the necessary intelligence to judge the utility and convenience of admitting the metric system in the republic" that was made public in 1854.[57] The name of Payno was among those of six other former Ministers of Finance[58] and current and forthcoming influential political figures, like Miguel Lerdo de Tejada (future Minister of Finance himself and older brother of the future president of the republic, Sebastián), the French merchant Joseph Yves Limantour (father of José, who would became a powerful Minister of Finance in Porfirio Díaz's cabinet), and the engineer Manuel Fernández Leal (Minister of Development during the Díaz regime and the person in charge of supervising the actual implementation of the metric system in the 1890s).

Despite this early backing, Payno changed his opinion on this matter and in the 1870s he penned a series of newspapers articles on Mexican monetary and metrological policy, echoing (knowingly or not) some of the ideas that Alamán had expressed two decades earlier. 1870 was the year when Mexico had for the first time in circulation decimal coins in all denominations (gold coins of $20, 10, 5, 2.5, 1; silver coins of $1,

[56] Nicole Giron, "Manuel Payno, el ir y venir por la secretaría de hacienda," in *Los secretarios de hacienda y sus proyectos (1821-1933),* ed. Leonor Ludlow (Mexico: UNAM, 2002), 351-397.

[57] "Pesos y medidas," *El Siglo Diez y Nueve,* September 14, 1854.

[58] The other five were Manuel Merino, Antonio de Haro y Tamariz, B. Gutiérrez, Manuel Piña y Cuevas, and Pedro Fernández del Castillo.

50¢, 25¢, 10¢, 5¢; and a one cent copper coin).[59] Besides following a decimal progression, the images in the obverse and reverse of the coins were redesigned. The eight-real coin featured in its reverse a liberty cap (Phrygian cap) with rays behind, and it was called "resplandor" (brightness). The new decimal pesos featured a balance scale, a scroll with the word "ley" (law), a sword on the back, and a small Phrygian cap on the top; they were called "balanza" (balance) (see Figure 11).

Figure 11. Reverse of Eight-Real Peso and Decimal Coin

	
Eight-real peso with liberty cap in the reverse; it started to circulate in 1824, the year of the adoption of the republican constitution. It was minted, with interruptions, until 1897. The coin was known as "Resplandor."	Fifty-cent coin with the new design used in the reverse of the new decimal coins which temporarily replaced (starting 1869), the piece-of-eight. Features a balance, a sword, a scroll, and a small liberty cap. The new decimal peso had the same weight and finesse as the old coins, but with a smaller diameter. I was known as "Balanza."

[59] Miguel L. Muñoz, "The Decimal Monetary System, its Adoption in Mexico," in *Antología Numismática Mexicana,* (Mexico: M. L. Muñoz, 1977), 286.

In his articles Payno questioned the pertinence of the new decimal currency,[60] strongly disapproved the ornaments in the coins, and underlined the difficulties that the decimal subdivisions would create among lay people (I will come back to this issue in chapter 6). More importantly, Payno was concerned with the negative effect produced by new pesos in foreign commerce.

Payno was seeing in reality what Alamán feared theoretically in 1849 with the introduction of decimal coins. It turned out that the new Mexican coins were not well received in foreign money markets. The problem was particularly acute in China, where merchants distrusted the decimal pesos, mainly because the smaller diameter and the new design generated suspicions of forgery.[61] This produced a cascading negative effect for the exports of minted silver, as the lack of interest in the Mexican pesos in China depreciated its value in Europe. For all practical purposes this meant that the new Mexican pesos saw their value reduced to the amount of silver they contained; in other words, people melted the coins to use the metal (which represented a loss in the market value of the silver and a waste of the minting costs).

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[60] Manuel Payno, "La nueva moneda," *El Siglo Diez y Nueve,* May 17, 19, 20, June 1, August 8, 30, and December 16, 1870; Manuel Payno, "Lo que sucede en la práctica con la moneda decimal," *El Siglo Diez y Nueve,* August 24, 1870. I follow here the reprint of those articles compiled in Manuel Payno, *Periodismo político y social,* vol. 1 (Mexico: Consejo Nacional para la Cultura y las Artes, 2001), 264-275, 289-294, 344-346, 370-377, 459-462 . These articles were followed two years later by "La cuestión de las dos monedas bajo su aspecto práctico," *El Siglo Diez y Nueve,* October 9, 1872, reprinted in Manuel Payno, *Economía* (Mexico: Consejo Nacional para la Cultura y las Artes, 2008), 269-280.

[61] Actually this was not the first time that the trust deposited in the Mexican peso by Chinese merchants was hurt after the Mexican government decided to made innovations in the design of its coins. In the 1860s Emperor Maximilian decimalized and changed the imagery in the silver and gold tokens. These new coins (the first decimal money actually produced and put in circulation in the country) showed the Emperor's effigy, instead of the traditional "resplandor" image. The collapse of Maximilian's regime and the subsequent end of the production of its imperial pesos—that were replaced by the old piece-of-eight—took care of that problem with international consumers of Mexican silver.

Payno went as far as asking the government to abandon decimal currency and return to the old 8-real peso without a single variation or innovation, and rejecting the metric system altogether (no matter that from the time when of Alamán's writings to the moment when Payno entered this polemic there had been considerable changes in the international landscape of international metrication; it was a period in which 18 new countries adopted the metric system, half of them from Latin America, besides Mexico itself, and the United States made the system legal and optional during that period as well). What the federal government did was not to stop the production of decimal pesos, as Payno wished, but to conduct a sort of "dual minting policy," with simultaneous production of the traditional piece-of-eight *and* decimal pesos. The decision to resume the production of the "resplandor" coins was in part a tacit acceptance of the soundness of Payno's arguments; but it was also triggered by the decision of Mexico's northern neighbor to challenge the Mexican silver coins in the Far East markets.

China, the Mexican Peso, and the United States Trade Dollar

In 1873—a few months after the publication of Payno's final installment in his series of articles against decimalization and the redesign of the silver peso—things took a turn for the worse for Mexico when new competition emerged for a share of China's consumption of silver coins. That year the United States mints started to produce the so called "trade dollars," made with the explicit purpose of penetrating into the Eastern market (and were not meant for domestic circulation).

Up to that point the regular American silver dollar was rarely accepted in China because it was lighter than the Mexican peso, among other reasons. As a result American merchants who wanted to conduct business in China needed to acquire piece-of-eight minted in Mexico (or "Spanish milled dollars" as they were also known in the United States). To avoid paying a premium to buy Mexican coins in the bullion market, the American federal government decided to create a new silver trade coin. The weight and composition of this new coin was intended to "give the American trade dollar and edge over the Mexican eight-real coins, and the hope was cherished that Chinese merchants would prefer the American product."[62] Between 1873 and 1878 the mints of Philadelphia, Carson City, and San Francisco struck tens of millions of silver trade dollars.

Since it was created to contest the supremacy of the Mexican peso, it is not surprising that the design of the trade silver dollar showed in its reverse an eagle in an almost identical position to the eagle in the Mexican peso, standing left with wings spread (see Figure 12).

[62] Q. David Bowers, *A Buyer's Guide to Silver Dollars and Trade Dollars of the United States* (Irvine: Zyrus Press, 2006), 362.

Figure 12. Eagles in the Mexican Silver Peso and the United States Trade Dollar

		
Representation of a Mexican silver peso (known in China as "eagle") in a Chinese moneychanger's handbook with drawings to recognize foreign coins (1836).[63]	Reverse of the Mexican silver peso (1849), the design was launched shortly after independence and was used, with some interruptions, throughout the century.	Reverse of the United States trade dollar (1873), the design that differs greatly from the eagle in the regular silver dollar and mimics the eagle in the Mexican peso.

Despite this well-planned strategy, the trade dollar experiment was short-lived. Several reasons account for its demise. Firstly, a large number of trade dollar coins entered domestic circulation—where it was accepted as legal tender—even though their intended purpose was to function only in foreign trade, and that conflicted with some monetary policies in the country (this in the middle of heated national debates about the nature of money). Secondly, a pronounced fall in silver prices in 1876 raised fears that every trade dollar coin contained only about 90 cents worth of silver, what opened the

[63] Catherine Eagleton and Jonathan Williams, *Money: A History* (Richmong Hill: Firefly Books, 2007), 147.

door for abuses and frauds. Lastly, a study on the effectiveness of the trade dollar in China showed that it only achieved limited penetration in that country. All this compelled the United States authorities to stop the minting of trade dollars in 1878.

The trade dollar was not the first or the final challenger to the Mexican silver peso's position in the Far East. England had produced in London, from 1863 to 1865, and later in Hong Kong (1866-1868) the *Hong Kong dollar;* Japan made a *trade yen* (1870-1875) follow by the *Boeki-gin* (1875-1877); France minted the *piastre de commerce* aimed for Indochina starting in 1885; and later a *British dollar* was made by England in Bombay and Calcutta (1895-1935). All of them were aimed to have a slice of the silver Eastern market. Finally, in 1899 China started producing its own silver coins, similar in weight and finesses to the Mexican peso.[64] But despite this stiff competition the Mexican peso continued to be extensively used in China until the early twentieth century.

The particular significance of the trade dollar for Mexico was, more than anything else, timing. The United States launched these coins during a period of instability in the Mexican monetary policy, caused by the desire to complete the transition to a decimal currency and to metric weights and measures. Mexico was at the crossroads of two waves of long-term globalization processes. On the one hand there was the silver eight-real peso representing what Serge Gruzinski calls the "Iberian globalization"[65] and the fading

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[64] Agustín F. Legorreta and José Antonio Bátiz, *El real de a ocho, primera moneda universal* (Mexico: Fomento Cultural Banamex, 1976), 18-19; Muñoz, "The Mexican Peso in the Far East," 194-199.

[65] On the idea of "Iberian globalization," or the "planetary dimension acquired by the [Spanish] empire," see Serge Gruzinski, *What Time Is It There: America and Islam at the Dawn of Modern Times* (Cambridge: Polity, 2010), 72; and more extensible in his *Les quatre parties du monde: histoire d'une mondialisation* (Paris: Martinière, 2004).

supremacy of the institutions left behind by the Spanish empire—institutions that reshaped the world from the sixteenth to the early nineteenth century and connected the Far East, the Americas, and Europe (not accidentally Philip II's realm was described as "the Empire on which the sun never sets"). On the other hand, there was the metric system, pointing to an emerging global regime that from the nineteenth century on has exponentially increased the material and intellectual exchanges among nations, regions and continents, based in part on new technical languages and word-wide conventions.

The poor acceptance in Europe of the new decimal peso, the lack of sympathy with which it was received in China, and the new competition in the Oriental silver market put the Mexican government in a tough position. Renouncing to keep producing the new coins would have halted the decades-long plan for a decimal currency. Conversely, stopping the production of old pesos (piece-of-eight) would have significantly damaged Mexico's most important international commodity (as silver represented closely to eighty per cent of exports income in the country).[66] Mexican global monetary connections were at odds with the upcoming international conventions. Adopting the French international measurement system meant abandoning the Mexican international currency. In an unexpected way Mexico's globalized past, inherited from the Colony, was halting its globalized future.

Mexican ingenuity found a non-orthodox, temporary solution to this problem. In 1873—three years after the new silver decimal "balance" pesos replaced the "liberty cap"

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[66] Marichal, "The Spanish-American Silver Peso," 47.

pesos—president Sebastian Lerdo de Tejada ordered that the old eight-real pesos should be produced again, but he did not stop the striking of the new coins. The decimal coins circulated parallel with the eight-real. This dual minting continued until 1897-1898, when Mexico turned completely to a decimal monetary system.[67] By and large, this split arrangement allowed the Mexican government to carry on their plans for decimalization and also to keep the production of the commodity sought by Chinese merchants.

Metric System, Universal Currency

A topic that Lucas Alamán did not contemplate in his reflections on money and measurement—and that was also left untouched by and Payno—but one that during those years received thoughtful consideration in international circles regarding the metric system and monetary reform, was the possibility of using the metric system itself (and not only the decimal progressions) as the basis for a new metric international currency that would allow interchangeability between different national moneys on the basis of a fixed amount of metal in a set number of grams.

During the decades of 1850 and 1860 the idea of "universal coinage unification" seemed promising and was widely discussed in Europe and the United States. In the Universal Expositions and the International Statistical Congresses—meetings that helped

[67] Muñoz, "The Decimal Monetary System, Its Adoption in Mexico," 287-288; Theodore Buttrey, *Guía de las monedas decimales mexicanas, 1863-1963* (Racine, Wisconsin: Casa Editora Whitman, 1963), 83. For an overview of the development of Mexican currency with abundant photographic examples, see *Mexican Coinage,* ed. Elena Horz de Sotomayor (Mexico: Banco de México, 2001).

greatly the cause of metrication around the world[68]—numerous thinkers and policy makers from various countries and professional backgrounds pushed forward the idea of an international metric gold coinage. The main arenas where these discussions took place were the Fifth International Statistical Congress (Berlin, 1863), the Paris Universal Exposition of 1867, and the International Monetary Conference of 1867 (the latter gathered government representatives from nineteen European countries and the United States).[69]

Many experts gathered there shared the conviction that a worldwide standard coinage was possible and needed. The ideological underpinning of this project was the ambition to secure a uniform standard of value and exchange, create the conditions for a larger market, and facilitate the free circulation of capital and goods. As historian Martin Geyer points out, the discussion on the international coin issue, as the metric system, were framed in terms of a "universal language," in this case a language of "measure of value"[70]—a theme to which I shall return soon.

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[68] Edward Cox, "The Metric System: A Quarter-Century of Acceptance (1851-1876)," *Isis* 13 (1958): 362-371.

[69] I follow the accounts made by Walter T. K. Nugent, *Money and American Society, 1865-1880* (New York: Free Press, 1968), 67-90; Martin H. Greyer, "One Language for the World: The Metric System, International Coinage, Gold Standard, and the Rise of Internationalism, 1850-1900," in *The Mechanics of Internationalism,* ed. M. Geyer and J. Paulmann (New York: Oxford University Press, 2001), 55-92; Steven P. Reti, *Silver and Gold: The Political Economy of International Monetary Conferences, 1867-1892* (Westport: Greenwood Press, 1998), 33-59; and Charles P. Kindleberger, "International Monetary Reform in the Nineteenth Century," in *Keynesianism vs. Monetarism and Other Essays in Financial History* (Boston: G. Allen & Unwin, 1985), 213-225; Luca Einaudi, *Money and Politics: European Monetary Unification and the International Gold Standard, 1865-1873* (New York: Oxford University Press, 2001), 147-150.

[70] Greyer, "One Language for the World," 81.

The rhetoric used to defend the plans for international coinage was almost identical to the one used many times to favor the metric system as an international measurement system. What's more, for some people these two projects were not just similar but were actually intertwined. An early example of this marriage of metric and monetary internationalism was the 1858 pamphlet *Universal Currency,* by T. A. Tefft (state commissioner of Industrial Art and Education for Rhode Island) which was both a plan for a common decimal currency in the United States, England, and France, and a guide to rendering the metric system of weights and measures "more simple and popular." As numerous others advocates of these plans, Tefft's was ultimately a plea for liberalization, commerce, and civilization. In his words, "the changing of money, in consequence of variations in the currencies of civilized nations, has long been burdensome and a senseless tax on commerce. […] Our material trading and traveling age demands that the feudal relic of many units of money should be abandoned, and that one standard of coinage should be current in every country traversed by the steam-engine."[71]

A decade later, in the midst of the diplomatic negotiations in France on international currency, Unites States senator John Sherman (chairman of the Committee on Finance and future Secretary of Finance and Secretary of State) wrote in a similar vein to Samuel Ruggles, the U. S. Commissioner to the Paris Exposition, to endorse Ruggles' efforts "to secure the adoption of the metric system of weights and measures:"

[71] T. A. Tefft, *Universal Currency: A Plan for Obtaining a Common Currency in France, England, and America, Based on the Decimal System; with Suggestions for Rendering the French Decimal System of Weight and Measure More Simple and Popular* (London: Effingham Wilson, 1858), iii.

> The tendency of the age is to break down all needless restrictions upon social and commercial intercourse. Nations are now as much akin to each other as provinces were of old. Prejudices disappear by contact. People of different nations learn to respect each other as they find that their differences are the effect of social and local custom, not founded upon good reasons. I trust that the industrial commission [of the universal exposition] will enable the world to compute the value of all productions by the same standard, to measure by the same yard or meter, and weigh by the same scales.[72]

And shortly later, in a report to the Senate on international coinage, Sherman made the case for uniformity in coinage of the United States and other countries framing the issue in the same liberal spirit:

> The inconvenience of different standards of value arises mainly in foreign commerce, in the exchange of commodities among nations. The intercourse between modern Christian nations is now more intimate and exchange more rapid than it was between provinces of the same country two hundred years ago. […] Every advance towards a free exchange of commodities is an advance in civilization. Every obstruction to a free exchange is born of the same narrow despotic spirit which planted castles upon the Rhine to plunder peaceful commerce. Every obstruction to commerce is a tax upon Consumption; every facility to a free exchange cheapens commodities, increases trade and production, and promotes civilization. Nothing is worse than sectionalism within a nation, and nothing is better for the peace of nations than unrestricted freedom of intercourse and commerce with each other. No single measure will tend in this direction more than the adoption of a fixed international standard of value by which all products may be measured, and in conformity with which the coin of a country may go with its flag into every sea and buy the products of every nation without being disconcerted by the money changes.[73]

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[72] John Sherman to Samuel Ruggles, May 18, 1867, reproduced in *John Sherman's Recollections of Forty Years in the House, Senate and Cabinet: An Autobiography* (Chicago: The Werner Company, 1896), 348.

[73] United States. Congress. Senate. Committee on Finance, *International Coinage: I. Report of Senator Sherman. II. Report of Senator Morgan. III. Bill to establish a uniform coinage. IV. Report of Mr. S.B.*

However, even if the majority of the participants in the conversations on universal currency were inspired by similar economic liberal ideals, they did not agree on the means to fulfill them. They faced a similar predicament to the one confronted by those interested in the creation of a global system of measurement: would it be better to use an existing currency and use it as the exclusive international standard or would it be preferable to design a completely new system and start from scratch? People were divided on this issue. Those inclined to the idea of using a currency model already in use suggested that an existing coin (mainly the gold franc) should serve as standard; those in favor of a start-afresh solution argued that it was better to create a completely new coin which amount of pure metal would be fixed in a round metric quantity.

Michael Chevalier, from France, and others favored the idea of using the metric system as the base for the new international currency. The plan consisted of a currency with decimalized subdivisions and gold coins weighed in a round number of grams. More specifically, they proposed to fix the gold content of the proposed new coin at exactly ten grams, i.e. a decagram (this unit of weight was informally used to name the members of this group as "decagramists"). This idea was seconded in the United States by congressman William D. Kelley, chairman of the House Committee on Coinage, Weights and Measures (who, like many other influential political figures in Washington favoring the metric system, was a radical northern Republican).

Ruggles (Washington: Govt. Print. Off., 1868), 4. On later work in Congress on these topics see House of Representatives, *Metric Coinage Report* (1880).

As they see this issue, what the metric system of weights and measures offered was the opportunity to unify coinage on a "scientific basis." Scientists, politicians, academics, and journalists who backed "metric currency" were seduced by the "theoretical neatness of an international metric gold coinage,"[74] as this was a way to interlink universal standards of value, weights, and measures.

The majority of the people involved in these discussions, however, preferred the option of employing an existing system as the common international standard. Ruggles was the leading voice in this camp, and he received considerable support from the federal government to push his agenda in the international meetings. For this group the scientific elegance sought by decagramists was too idealistic and the option of a new currency, different from all existing monetary systems, was unrealistic. The practical thing to do, they said, was to adopt an already existing currency as the base for the international standard. Ruggles wanted to equate the American dollar and the British pound sterling to twenty-five gold francs, which would have required England and the United States to modify the weight of their respective currencies slightly, and for France to abandon silver (a central part of the discussions was devoted to the problem gold monometalism versus bimetallism).[75]

The support received by Ruggles's plan of using the French franc as the basis for uniform coinage for all nations and the abolition of silver as a monetary standard (plus some other principles like universal finesses of .900 and the employment of decimal

[74] Nugent, *Money and American Society*, 70.

[75] Nugent, *Money and American Society*, 70.

subdivisions) killed the decagramists hopes. The problem for the metric camp with this initiative was that contrary to France's silver coins which were measured by exact gram units, the gold franc was not; thus the demand to follow the French *gold* currency (which was not metric) was pretty much what slayed the possibility of a new international metric-based monetary system.

Ultimately, the 1867 conversations in the Monetary Conference did not amount to much. Delegates of many countries were reluctant to commit to any binding phrasing or agreement—something not surprising considering how delicate the topic of monetary policy is. Good intentions were expressed and future conversations planned, though. And indeed the topic of universal currency was kept alive in the press, specialized literature, and in other international meetings; but it never regained its full impetus.[76] The Franco-Prussian war damaged in a definite way the spirit of internationalism that fed the Paris meetings; the subsequent demise of Napoleon III (who was very interested in exporting the franc and the meter) and the changing balance of power in Europe stripped France of much of its power to set conditions in international agreements, damaged even further the prospectus of metric currency.

A curious legacy of the intersection between currency and the metric system in the United States—which today is no more than a footnote in the history of metrology and numismatics—was the design of the five cents nickel coin. Introduced in 1866 (the

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[76] Still in 1879 there were conversations in the United States Congress about metric coinage, see *Report of the Committee on Coinage, Weights, and Measures: Part 1, on the Adoption of the Metric System of Weights and Measures, Together with Documents and Statistics Relating to the Subject; Part 2, on Metric Coinage* (Washington: Government Printing Office, 1879), 203-210.

same year when the metric was made legal in the country), nickels were specified to weigh exactly 5 grams, i.e. one gram per cent (and even today the 5-cent nickel coin weights 5.0g). Later, in 1873, the silver coins of the United States of smaller denominations than one dollar were also given metric weights, with the 10, 25 and 50-cent silver pieces weighing one gram for each 4 cents. The convenience of this arrangement for everyday life was noted by some commentators who observed that with the nickels "each man carries his own letter-weights in his pocket" and that "two 10-cent pieces will balance one nickel, all of these coins may be conveniently used as weights to check metric scales."[77]

Some people wanted to go further and they kept using the metric system to push the Unites States take the lead in the issue of international currency. For example, in 1896 congressman Charles W. Stone (who in 1901 favored of a bill for the adoption of the metric system) published in *The North American Review* an article on "A Common Coinage for All Nations." There he described how "A 'common measure' has already spread over most of the civilized world, and the probable adoption of the metric system of weights and measures in the near future by the United States, Great Britain, and Russia will make that system universal and save much of the friction and loss which have heretofore been the outcome of diverse systems." And after suggesting that the dollar may serve as the basis for new international money, he asked for

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[77] A. E. Haynes "Metric Department; Progress of the Metric System of Weights and Measures," *Hillsdale Standard*, December 4, 1877; *Indianapolis News,* April 28, 1921.

> a currency that would change value at no national frontier, that would defy the exactions of brokers and money-changers, that would carry the badge of civilized life into every clime, exchangeable for the products of every tribe and nation, the measure of all labor and value, uniform, universal, and unchangeable, is a desideratum the attainment of which is worthy of the most zealous efforts of the patriotic citizens of every nation.[78]

The close connection between a international currency and the desire to spread metric weights and measures in the United States can be clearly seen in the professional affiliations of some of the key actors involved in the universal currency debates. For example, congressman John Kasson and senator Charles Sumner—the driven forces behind the 1866 legislation that made the metric system legal in the country, as I indicated in chapter two—supported international coinage unification and the participation of the United States in the 1867 Paris Monetary Conference.

More telling is the fact that in the 1870s Kasson, along with Samuel Ruggles, and E. B. Elliott (a government actuary in the Treasury Department who prepared a report on metric currency) were members of the first openly pro-metric association in the country, the American Metric Bureau—with Elliott working in the Bureau's Committee on International Coinage.[79]

And not accidentally, Frederick Barnard, president of the American Metrological Society (the other significant nineteenth-century pro-metric body), published at least four pamphlets and papers on international coinage and the possibility of an invariable

[78] Charles W. Stone, "A Common Coinage for All Nations," *The North American Review* 476 (1896): 55.

[79] *The Metric Bulletin* 7 (1877): 102. On some of the work made by Elliott as part of his work in the Treasury Department, see E. B. Elliot, "On the relative value of Gold and Silver for Series of Years," in *Proceedings of the American Association for the Advancement of Science* 17 (1868): 122-123; "Report of Mr. E. B. Elliott on the Metric System of Coinage," *New York Times*, February 18, 1869.

standard of value[80]—at the same time as he was leading the cause of the metric system and working with other members of the Society to develop the plan that culminated in our present international standard time zones. This interest of the Metrological Society was so explicit that its first objective—as stated in its Constitution—was "To Improve existing system of weights, measures, and moneys, and to bring them into relations of simple commensurability with each other."[81]

But despite the failure to bring to fruition metric coinage (or any other form of universal currency), nineteen-century metric devotees in America would have still another chance to espouse metric measures with liberal economic interests, this time not necessarily a "universal" scale, but at a continental one.

3. PAN-AMERICAN MEASURES AND THE FIGHT FOR A "UNIVERSAL LANGUAGE FOR COMMERCE"

One of the defining moments in the history of the metric system in Mexico, as I mentioned in the previous chapter, was the 1889-1890 First International Conference of American States, which represented the point of departure for the introduction in practice

[80] Frederick A. P. Barnard, *International Coinage* (London: William Clowes, 1874); *Mono-Metallism, Bi-Metallism, and International Coinage* (New York: The S.W. Green Type-setting Machines, 1879); *The Possibility of an Invariable Standard of Value* (New York, 1879); *The Regulation of Time; International Coinage; the Unification of Weights and Measures; Sea-Signals* (London: W. Clowes and Sons, 1881); "On the Relation to the Public Welfare of Changes in the Volume of Money and on Money Standards," *Proceedings of the American Metrological Society* 2 (1882): 202-230.

[81] *Constitution of the American Metrological Society,* as revised in 1888. For other examples of the work of the AMS: American Metrological Society, *The Metric System: Detailed Information as to Laws, Practice, Etc.* (New York: American Metrological Society, 1891); George Eastburn, *The Metric System* (New York: American Metrological Society, 1892).

of the metric legislations that have been around since 1857. But that conference also started a period of intense pro-metric activity in the United States.

The plans for a conference of American countries started to take form in 1881 when the United States Secretary of State, James Blaine, conceived the plan to invite representatives from Latin American countries to a hemispheric conference. Formal invitations were dispatched that same year, but the assassination of President James Garfield and later the resignation of Blaine from his post halted the whole endeavor. It was in 1888 when the plan was resurrected and the First International Conference of American States deliberated from November 1889, through April 1890, in Washington D.C. (this was actually the United States first experience hosting an international assembly of governments).[82]

The ultimate interest of the United States government to arrange this conference was to strengthen the competitive position of American businessmen in Latin America. This interest was triggered in part by the fact that commerce between the United States and Latin American countries had increased steadily in the previous decades. From 1870 to 1900 that trade doubled in volume. In the 1870s Latin American consumed more than 8 per cent of US exports and supplied more than 30 per cent of the imports; and by the early 1890s US exports to the South of the continent got to little more than 10 per cent. However, European rivals had outperformed their North American counterparts in their trade with Latina American countries during those years. With the Pan-American

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[82] James F. Vivian, "The Pan American Conference Act of May 10, 1888: President Cleveland and the Historians," *The Americas* 27 (1970): 185-186.

conference Blaine wanted to displace European competitors by building a stronger commercial bond with Latin America.[83]

The stated aims of the Conference—which gathered a total of 18 countries—were preserving peace on the continent, promoting prosperity, establishing a customs union to facilitate trade between the nations of the hemisphere, improving communication between ports, protecting patents and copyrights, sharing forms of classification and valuation of merchandise, creating an inter-American train, an international American bank, establishing an office to collect and distribute information of interest to the American countries, adopting a common silver currency (to be issued by each government but accepted as legal tender in commercial transactions in all the nations), and a uniform system of weights and measures.[84]

The idea of a common currency and common weights and measures resembled some of the key interests preset in the Paris conference of 1867—but now in a continental context. Since the plans of the conference were announced in 1888 some observers saw the opportunity to finish what was left incomplete in the European meetings. See for example this newspaper piece:

> Every friend of the progress of civilization and fraternity among nations and peoples will look with interest to the meeting of the conference [...]. The exigencies of commerce, the

[83] Edward Franklin Cox, "A History of the Metric System of Weights and Measures: With Emphasis on Campaigns for its Adoption in Great Britain and in the United States prior to 1914" (PhD diss., Indiana University, 1956), 557; David Healy, *James G. Blaine and Latin America* (Columbia: University of Missoury Press, 2002), 145.

[84] Carnegie Endowment for International Peace, *The International Conferences of American States, 1889-1928* (New York: Oxford University Press, 1931), 6-47.

> adaptation of scientific discoveries to meet the wants of an advancing civilization among peoples newly made neighbors, and brought into juxtaposition by the laying of electric cable, and by improvements in ocean steam navigation, clearly indicate the need of uniformity in the modes of doing business, in estimating the quantities and values of exchangeable commodities, those prime factors in the intercourse of mankind. The calling of the conference evidently means for the people of the United States the early introduction and general use of the metric system. The time is propitious. The relative values of gold and silver have so changed everywhere as to call for a revision of standard units of value. It will be in the power of this conference to do what the several monetary conferences assembled in European capitals, from time to time, have failed to accomplish; namely, the unification of money for the civilized world.[85]

Contrary to the suggestion of this editorial, the conference did not have the power to set any resolution on monetary (or any other kind of) policy; it could only make recommendations that would not bind any participant country.[86] But the newspaper was correct in assuming that when the plan for the conference called for a common system of weights and measures in the Americas, it actually meant the adoption of the metric system (which was seen here, as in the 1860s European diplomatic and commercial meeting, as an instrument of civilization).

The Conference formed a Committee of Weights and Measures, which heads were Jacinto Castellanos, a diplomat from El Salvador, and Clement Studebaker, an industrialist from Indiana known as the world largest maker of carriages and wagons.[87] The Mexican delegate, Matías Romero, played a significant role in the discussions of the

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[85] "An Important Conference," *Evening Transcript,* July 6, 1888.

[86] Healy, *James G. Blaine and Latin America*, 146.

[87] Healy, *James G. Blaine and Latin America*, 147.

committee.[88] Romero was an experienced Ambassador in Washington and a two times Minister of Finance.[89] A long time believer in the principles of economic liberalism, Romero was akin to the overall principles of the Conference and supported, like the other representatives, the idea that the metric system should became the system of measurement used in the whole continent.

On January 24, 1890 the Committee of Weights and Measures concluded its works with this single recommendation on the topic of "a uniform system of weights and measures": "The international American Conference recommends the adoption of the metrical decimal system to the nations here presented which have not already accepted it."[90]

This resolution had two main objectives. The first was to pressure the countries which have not adopted the metric system yet—mainly the United States—to pass new legislation making the metric the only legal system. The second (even though it was not in the print), was to compel the countries that had already adopted the system to actually enforce it (this because in the large majority of Latin American countries the metric legislation was just nominal). The second of these objectives was much more effective that first one, since it was this ambitious plan of continental free market and economic integration that gave Mexico and other Latin American governments the determination to

[88] International American Conference, "Report of the Committee on Weights and Measures," in *Reports of Committees and Discussion Thereon* (Washington: Govt. Print. Off, 1890), 77-80.

[89] On the participation of Romero in the Conference see Chester C. Kaiser, "México en la primera Conferencia Panamericana," *Historia Mexicana* 11 (1961): 56-80.

[90] International American Conference, "Report of the Committee on Weights and Measures," 80.

finally introduce the metric system in practice. By doing that, Latin American governments expected that the United States, as the host nation in the Conference and a signer of the agreements, would also move forward in its metrication process.

We know now that the first objective of the recommendation of the Committee of Weights and Measures—the adoption of the metric system to the countries in the Americas which had not already accepted it—did not come to fruition. In a tragic irony for metric supporters, the country that organized and hosted the conference that did so much for metrication in the hemisphere became the sole nation in the continent to fail to go metric. But this fiasco was not for lack of trying, as the conference was the starting shot for a large campaign in favor of the metric system—and Latin America would be at the center of these discussions.

The weights and measures report of the Pan-American conference kick started a period in which the adoption of the metric system as the official and *exclusive* system of measurement in the United States looked, if not imminent, at least highly probable. In the years after 1890 there was considerable movement, inside and outside Congress, in favor of metrication.

Breifly after the conference was over Blaine sent a letter to the President, accompanying the proceedings of the conference, with a proposal to adopt the metric in customs service of the United States and a draft of bill for that purpose to be considered by Congress.[91] And this would be only one among many bills regarding metrication discussed by legislators in the following years.

In 1896 metric legislation received considerable support in the House of Representatives, with key members in the Committee on Coinage, Weights, and Measures favoring metrication, like Charles W. Stone[92] (who had also supported the idea of international metric currency). The report prepared by the Committee highlighted the fact that Latin America had gone metric already and asked "Why should the United States alone of all the republics of the Western Continent persist in its adherence to a cumbrous and antiquated system, if it may be called a system, of weights and measures, and thus let much of the commerce of its sister republics which it should attract and enjoy drift to the metric-using nations of Europe?"[93] The law for compulsory and exclusive of metric measures in the country proposed by the Committee was a few votes away from being accepted.[94] Feeling victory close, many pro-metric individuals and organizations launched numerous efforts to secure favorable legislation.

In January 1898, during the Third Annual Convention of the National Association of Manufacturers, industrialist Albert Herbert read the report of the Committee on

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91 Cox, "A History of the Metric System of Weights and Measures," 559.

92 See "Proposed Legislation in Regard to the Metric System," *Science* 65 (1896): 457-463.

93 H. R. Report No. 795, quoted in Cox, "A History of the Metric System of Weights and Measures," 572.

94 Charles F. Treat, *A History of the Metric System Controversy in the United States* (Washington, DC: National Bureau of Standards, 1971), 102-112; Cox, "A History of the Metric System of Weights and Measures," 577.

Language, Weights and Measures,[95] a lengthy and spirited document that asked for Congress to make the metric system of weights and measures the only legal system in the United States, starting in 1901. The report maintained that the metric system was an instrument to foster universality and compare it to other globally accepted codes: "a very important part of the language of commerce is what is properly called the 'language of quantity,' or the terms and divisions employed in determining weight and measure. [...] The Arabic numerals are a labor-saving, trade-extending tool, and as a language of commerce it is today the only language that is absolutely universal. These signs when written or printed, are understood in all commerce everywhere on Earth."

The report finalizes portraying an enthusiastic future of progress in which the metric system would be the norm of the day and old ideas—as old systems of measurement—would be thrown away:

> We live in an age of marvelous progress. We have now machines which annihilate space and enable us to see and hear and talk over the distance of half a continent, which reproduces the speech of yesterday in its exact tones, and transmit to us with the actual photograph of the speaker if it is desired. Man is entering the twentieth century, equipped with inventions which will compel him to overcome his present ultra conservatism. There is clearly no obligation to retain in our later and higher civilization any more of the past than is entirely suited to our altered condition. There is equally the necessity to find new tools for our new and greater needs—eliminating all waste and discarding the old

[95] The members of the Committee on Language, Weights and Measures were: Albert Herbert (chairman pf the committee), president of Hub Gore Makers; Charles A. Schieren, of C. A. Schieren & Co. and ex-mayor of Brooklyn; Charles H. Harding, of Erben Harding & Co.; Henry Fairbanks, vice-president of E. and T. Fairbanks Scale Co.; Theodore C. Search, Manufacturer, president and founder of American National Association of Manufacturers; and Andrew Carnegie.

framework of past customs as we discard the skins and blankets of the patriarch for the modern clothes of the citizen.[96]

Attached to the report was a letter by Andrew Carnegie—member of the Language, Weights and Measures committee—who could not attend the session: "I beg to say," Carnegie's letters said, "that [the metric] system is one of the steps forward which the Anglo-Saxon race is bound to take sooner or later. Our present system inherited from Britain is unworthy of an intelligent nation of today. The advantage we possess over Britain in our decimal dollar system as compared with their pounds, shillings, and pence, would be fully equaled by the adoption of a metric system of weights and measures."[97]

Despite some objections to the idea of industrialist binding themselves by a legal chain to the metric system and risking to remake "every tool in the hands of American manufacturers," the report was accepted by the convention and referred to the Committee on Resolutions.[98]

In 1901 the National Bureau of Standards was created, and his director, Samuel Stratton, was an open and unapologetic supporter of the idea of the United States going

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[96] A typed copy of the report can be seen in Melvil Dewey Papers, box 67. A somewhat modified version of the text was reproduced in *World Metric Standardization: An Urgent Issue*, edited by Aubrey Drury (San Francisco: World Metric Standardization Council, 1922), 38-44.

[97] Melvil Dewey Papers, box 67.

[98] "Manufacturers Meeting: Opening of the Third Annual Convention of the Association in Masonic Temple," *New York Times,* January 26, 1898.

metric. To this end he wrote articles, participated in congressional hearings, and collaborated with pro-metric organizations.[99]

That same year the National Board of Trade—an organization interested in, among other things, securing uniform trade practices[100]—passed a resolution backing a pro-metric bill before Congress, arguing that "The use of weights and measures is universal in all civilization, and uniformity in such matters is important in economizing time and in facility for adjustment of calculations in every branch and line of industry," adding that "the decimal plan, which is the basis of the metric system, has become the accepted and established form of notation throughout the entire civilized world."[101]

Early in 1902, in hearings on the subject of the metric system before the House Committee on Coinage, Weights, and Measures, the inventor Elihu Thomson, of General Electric, was one of many supporters of the metric system.[102] And in a supplemental hearing the British physicist William Thomson (Lord Kelvin), arguably the most

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[99] Cox, "A History of the Metric System of Weights and Measures," 584-587. For a profile of Stratton life see A. E. Kennelly, *Biographical Memoir of Samuel Wesley Stratton, 1861-1931* (National Academy of Sciences, 1935).

[100] In a related issue that implicates the National Board of Trade and plans for metrological reform, the Board was involved in the 1860s and 1870s on the diffusion of the so called "cental system." The cental was unit of one hundred pounds and was devised to replace the different existing kinds of *bushel*, especially for the commerce of grain. It was used for some time in mayor American cities (and there are reports of its adoption in Liverpool and other English cities). See T. A. Bryce, *The American Commercial Arithmetic* (n. p.: C. G. Swensberg, 1873), 366; John Groesbeck, *The Crittendon Commercial Arithmetic and Business Manual: Designed for the Use of Merchants, Business Men, Academies, and Commercial Colleges* (Philadelphia: Eldredge & Brother, 1871), 224; "The Metric System," *The Shareholder: A Railway, Banking and Investors' Gazette*, December 26, 1879, 3; *Daily Evening Traveler,* July 23, 1879.

[101] National Board of Trade, *Proceedings of the Thirty-First Annual Meeting of the National Board of Trade* (Philadelphia: John R. McFetridge & Sons, 1901), 55, 73-74, 299-300. That same resolution was supported again in 1902, see National Board of Trade, *Proceedings of the Thirty-Second Annual Meeting of the National Board of Trade* (Philadelphia: John R. McFetridge & Sons, 1902), 137.

[102] *Hearings before the Committee, Feb. 6-March 3, 1902, on Bill H. R. 2054* (Washington: Government Printing Office, 1902), 1-5.

celebrated scientist of the time, went to the United Stated Congress to plead American lawmakers to pass favorable metric legislation under discussion—this after he made several public interventions in England urging the Parliament to take action in favor of the metric system.[103]

Besides these groups—scientists, inventors, public officials, legislators, and traders—educators had for a long while been in favor of metric adoption (and continued to be for decades to come). Among them was Melvil Dewey (founder in 1876 of the first pro-metric organization in the country, the American Metric Bureau), who championed the metric system as part of his efforts to improve public education (along with spelling reform and library efficiency, the field in which he became notorious for his *decimal* classification system), and who received generous donations from Andrew Carnie to continue with his efforts.[104]

In general terms, this coalition portrayed a vision of universality in which humanity, in a modern world, would share common codes and languages. In this world the metric system was compared to Hindu-Arabic numerals, the alphabet, a universal calendar, musical notation, and international auxiliary languages like Esperanto (and sometimes even with a single universal language and a single currency). On the other hand, the more utilitarian interest of helping the international trade of the United States

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[103] *Supplemental Hearing on the Subject of the Metric System of Weights and Measures: Hearings before the United States House Committee on Coinage, Weights, and Measures, Fifty-Seventh Congress, First Session, on Apr. 24, 1902* (Washington: Government Printing Office, 1902), 1-11. The press described the event stressing the "remarkable spectacle of a member of the British nobility appearing before a Congressional committee," "Lord Kelvin a Witness," *New York Times,* April 25, 1902.

[104] See Hector Vera, "Melvil Dewey, 'Metric Apostle,' " in *Metric Today* 45 (2010): 1, 4-6.

was married with that universalistic worldview. To convey these ideas they frequently depict the metric system as a "universal language."

At this point the pro-metric movement had considerable momentum in its favor and few people showed opposition to it. In newspapers, journals, and congressional hearings metric advocates visibly outnumbered their counterparts.

But later in 1902 the tide started to turn. In the meeting of the American Society of Mechanical Engineers some members raised alarm about a government-mandated change in the measurement system. Frederick A. Halsey (1856-1935), a mechanical engineer from New York, and Samuel S. Dale (1859-*ca*. 1935), a textile industrialist from Boston, presented strong opinions warning about the dangers of adopting the metric system (and they become the voice of the anti-metric movement on America for decades to come).[105]

Halsey in particularly was instrumental due to his reputation, gained in part for his inventions (like the "slugger" rock drill) and for his work on a premium plan of paying for labor in the 1890s, also known as the "Halsey Premium Plan" (a widely recognized method, contemporary of the work by Frederick Taylor—another mechanical engineer—on industrial efficiency).[106] Halsey dedicated the rest of his life to the cause of opposing metrication in America, wrote profusely about the topic (both in technical journals and

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[105] As an illustration of Dale's position on metrication: Samuel S. Dale, *The Foreign Attack on Our Weights and Measures* (Boston, 1926).

[106] F. A. Halsey, "The Premium Plan of Paying for Labor," *Transactions of the American Society of Mechanical Engineers* 12 (1890): 755-780. On Halsery's carrer see Robert R. Jenks, "Frederick Arthur Halsey," *American National Biography Online.* Feb. 2000. http://www.anb.org/articles/13/13-00688.html.

the popular press), and became the single most visible anti-metric figure in American history.[107]

A lesser known figure, Dale was editor of the magazines *Textil World* and *Textil World-Record,* and from 1815 owner of *Textiles*. As Halsey, Dale spent an astonishing amount of time, energy, and resources during almost half of his life to the defense of customary weights and measures. He also produced a deluge of articles, pamphlets, and letters, and was a constant presence in conferences, meetings, and public discussions (besides amassing a large collection of books on historical metrology that he later donated to Columbia University alongside his enormous correspondence).

In a private letter to Charles H. Harding, President of the Bank of North America, Samuel Dale articulated his social and economic vision with a simplicity and cohesiveness that was not present in his many pamphlets, and that in many ways summarizes the position of many other metric opponents:

> the defense of our weights and measures has become part of that greater problem involved in the defense of all of our established institutions. That time has come for all of us to stand by the United States of America. That is a duty we owe to those who come after us in return for what others did for us before we saw the light of day. […] Protection for our form of government, our language, law, weights and measures and our right to consume what we produce and produce what we consume. That protection is our first duty. We shall win if everyone does his or her duty.[108]

[107] For a couple of examples of Harlsey's non-specialized anti-metric articles, see "Disputes Metric Success," *New York Times,* August 23, 1925; and "Continuing the Metric War," *New York Times,* June 5, 1927.

[108] Samuel S. Dale to Charles H. Harding, March 26, 1919 (Samuel Dale Papers, vol. 7).

Following the example of the British sociologist Herbert Spencer (who in 1896 sent to all members of the House of Commons, to some members of the House of Lords, and to all representatives in the United States Congress copies of his pamphlet *Against the Metric System*[109]—as I will detail in the following chapter) Halsey and Dale elaborated their main arguments questioning the alleged advantages brought by metrication and the assumed technical superiority of metric over customary units. Certainly, Halsey and Dale employed nationalistic cries to attack the metric system (as was characteristic of metric opponents during the nineteenth century), but that was not at the core of their arguments. These were educated and intelligent "practical" men who possessed the intellectual resources to challenge scientists' claims in their own terrain.

Spencer began what he called a "rational opposition" to the metric system and Halsey and Dale followed him through. They articulated their ideas in what became the single most influential book in the history of the metric system in America, *The Metric Fallacy*.[110] The book revolved around the idea that based on practical and economic grounds the transition to the metric system was undesirable. More specifically, Halsey argued that changing a system of weights and measures was enormously difficult and the transition would never be fully completed; that the change of system represented the destruction of the existing mechanical standards; that foreign commerce does not require

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[109] Herbert Spencer, "Against the Metric System," in *Various Fragments* (New York: D. Appleton and Company, 1914), 130-156.

[110] The first edition of Halsey's *The Metric Fallacy* was published in a single volume with Dale's *The Metric Failure in the Textile Industry*. The second edition of the book, this time without Dale's text was published as Frederick A. Halsey, *The Metric Fallacy: An Investigation of the Claims Made for the Metric System and Especially of the Claim that Its Adoption Is Necessary in the Interest of Export Trade* (New York: The American Institute of Weights and Measures, 1920).

the adoption of a new system in manufacture; that for industrial processes the metric system was not better suited than the English system; and that England and the United States have "the simplest and the most uniform system of weights and measures of any country the world."[111]

Finally, in the *Metric Fallacy* Halsey also questioned the mere possibility of implementing a universal system: "The experience of a century has shown that the idea of a universal system of weights and measures is an 'iridescent dream.' We must make up our minds to get along with diverse systems of weights and measures in the world as we do with divers languages and systems of currency."[112]

This nascent opposition to the metric system, based on economic arguments, was not restricted to mechanical engineers, and soon enough other groups and associations expressed similar beliefs.

The National Machine Tool Builders Association passed, in 1902, a resolution protesting the prospect of metrication in America, arguing that "the adoption of the metric system would entail an enormous first cost of new equipment to conform to the

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[111] Frederick A. Halsey and Samuel S. Dale, *The Metric Fallacy* and *The Metric Failure in the Textile Industry* (New York: D. Van Nostrand, 1904), 16-17; see also Cox, "A History of the Metric System of Weights and Measures," 606-617.

[112] Halsey *The Metric Fallacy*, 127. As part of their reaction against the introduction of the metric system, Halsey and others developed a not fully articulated but evident defense of diversity as positive value, not only in the somewhat limited field of technical standards, but in broader cultural aspects, they critiqued, for example, what they called "over standardization" or applauded the defense the of traditional national languages. On this issues, see "Over-Standardization," *Bulletin of the American Institute of Weights and Measures,* October 1, 1923, 3; and in that same publication "Elusiveness of World Uniformity," July 1, 1924, 14.

new standards and a constant increased cost in the maintenance of a double standard for repairs and renewals, and a consequent increased cost of the product to the consumer."[113]

That same year the National Association of Manufacturers, forgetting its fervent endorsement of the metric system just four years ago, adopted a mildly negative resolution asking for stopping any immediate change in the country's weights and measures: "It appears to this association, first, that the compulsory adoption of the metric system would probably affect the manufacturers interests of this country as follows: One-third who are exporters to European countries and dependencies would be benefited; one third who do business in this country and all other countries would neither be benefited nor greatly injured; one third who do business in this country and in England and dependencies would be seriously injured. For all this the expense and incontinence would be very great. In view of these conditions and of the further fact that the metric system is already legalized for the use of those who find it profitable, this association recommends that no further action can be taken on this matter at this time."[114]

By 1904 the members of the National Association of Manufacturers completed the U-turn from metric enthusiasts to hostile adversaries of metrication and asked

[113] *Resolution and Protest of the National Machine Tool Builders Association*, 1902.

[114] Quoted in "Manufacturers and the Metric System," *New York Times,* April 25, 1902. See also Albert K. Steigerwalt, *The National Association of Manufacturers, 1895-1914* (Ann Arbor: University of Michigan, 1964), 93-94.

Frederick Halsey to represent them in a Congressional hearing, with Halsey delivering a forceful testimony against any change in current metrological legislation.[115]

Overall, for the anti-metric movement at large, Halsey and Dale articulated the ideas to oppose metrication, and the National Association of Manufacturers provided the political muscle to stop metric initiatives in Congress.

It is relatively easy to understand why manufacturers opposed mandatory metrication, as it was they who faced the financial burden of retooling and acquiring new equipment if metric legislation was passed.[116] Why mechanical engineers joined manufacturers in this battle is not as evident.[117] By and large, the opposition by engineers and manufacturers against compulsory metric legislation should be also framed in the larger context of the adamant defense by American industries of their perceived right to set technical standards by themselves (without government intromission), and the reluctance by the federal government to intervene decisively into the matter, in one direction or the other—something it almost never did, not even in cases where national

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[115] *The Metric System: Hearings before the Committee on Coinage, Weights, and Measures on H. R. 93 (58th Congress, 1st Session); H. R. 2054 (58th Congress, 2d Sessions), and H. R. 8988 (59th Congress, 1st Sessions)* (Washington: Government Printing Office, 1906), 1-19.

[116] For an analysis on the distribution of costs of going metric (for a different national case, though) see Roger Faith, Robert McCormick, and Robert Tollison, "Economics and Metrology: Give'em an Inch and They'll Take a Kilometre," *International Review of Law and Economics* 1 (1981): 207-221.

[117] For some answers to this question see Colleman Sellers, *The Metric System: Is It Wise to Introduce It into Our Machine Shops?* (Philadelphia: American Society of Mechanical Engineers, 1880); Monte A.Calvert, *The Mechanical Engineer in America, 1830-1910: Professional Cultures in Conflict* (Baltimore: Johns Hopkins Press, 1967), 179-186; Bruce Sinclair, *A Centennial History of the American Society of Mechanical Engineers, 1880-1980* (Toronto: University of Toronto Press, 1980), 46-60; Robert R. Jenks, "Governing in the Absence of Government: The Birth and Development of the United States Industrial Standards System" (PhD diss., University of California, Santa Barbara, 1999), 128-159. Also of interest in this context: Leo Marx, *The Machine in the Garden: Technology and the Pastoral Ideal in America,* (New York: Oxford University Press; 1964), 202 ff.

coordination seemed highly desirable, like standard time zones and the daylight savings time.

Correspondence between Dale and Marshall Cushing, Secretary of the National Association of Manufacturers, in 1906 shows how the Association used its political influences to oust key pro-metric members of the Committee on Coinage, Weights and Measures in the House of Representatives, starting with its chairman, James Southard (who lost his nomination in the Republican Party). Lucius Littauer and Solomon Dresser, other active metric proponents in the committee, abandoned congress as well. Referring to these events Dale wrote to Cushing, "I think I see in these events the fine Italian hand of Marshall Cushing." To which Cushing responded "It is, as I can say to you only in the strictest confidence, of course, that I am closely in touch with the [Republican] party managers, and I think that we have reason to fear nothing in the future if political pressure can be made to enter into the situation at all. In other words, we are entitled to feel good and yet to keep our ammunition dry."[118]

In the long run, the opposition by the National Association of Manufacturers and the mechanical engineers to the metric legislations proposed during the first two decades of the twentieth century proved to be crucial in the ultimate failure by the United States to adopt the metric system, as it effectively halted the momentum in favor of metrication

[118] Samuel S. Dale to Marshall Cushing October 6, 1906; Marshall Cushing to Samuel S. Dale, October 8, 1906 (Samuel Dale Papers, box 4). Cushing was also in close contact with Halsey in organizing the opposition against the metric movement; apparently he was instrumental in the anti-metric campaign, guiding where, when, and against whom actions should be taken.

and successfully made the metric topic a contentious political issue (something that dissuaded many politicians and public servants from showing any kind of support).

Then, midway through the first decade of the twentieth century a landscape of forces battling this metric war was set and it remained fairly stable for the next four decades or so:

- Favoring the metric system: exporters, scientists, and educators.
- Opposing the metric system: manufacturers and mechanical engineers.
- Congress, both in general and in legislative committees, was divided and prone to inaction.
- The federal government was divided as well, with some (particularly in the National Bureau of Standards) supporting metric legislation, but with other key actors legitimately interested in accomplishing standardization (like the Secretaries of Commerce and members of the military) rather reluctant to support any compulsory measure.
- The public in general was indifferent and rather uninformed about what the metric system was, what was useful for, and which were the implications of adopting it.

As the experiences of other countries have shown, the mandatory adoption of the metric system is a daunting and prolonged enterprise even when governments are unified, determined, and resourceful. But conditions in the United States (where the government itself was torn apart on the issue), in this critical juncture, only produced a long-lasting deadlock and failure to act.

Among the people in the federal government who in the following decades supported plans for standardization, but were unwilling to sponsor any mandatory legislation, the figure of Secretary of Commerce Hebert Hoover stands out. Hoover had the explicit intention of reducing the number of product sizes and simplifying the variety of manufacturing articles—this as a larger plan to improve the nation's *efficiency* (a key word in many of his endeavors). The creation of the Division of Simplified Practice, in the NBS was part of this ambitious project.[119] Simplify practices, from this standpoint, would help to protect customers and lower production costs. The grounds on which these principles were put in place were very broad and affected numerous industries, from face-brick dimensions and asphalt grades, to bread weight and food containers. As a newspaper described it:

> Secretary Hoover's Division of Simplified Practice has under way an endless campaign to eliminate needless sizes and styles. He has already brought about standardization of the sizes of bedsteads and bed springs, and is now working on blankets, lumber, metal lath, and other things. At the same time industry itself, through the American Engineering Standards Committee, is carrying out more than 100 other standardization projects. The public is going to hear a great deal about standardization and simplification from now on. Why not ask merchants of your city what commodities are in greatest need of standardization or simplification? Is it shoes, of which Mr. Hoover says there are more than half a million different styles on the market today? Is it lumber? There are, for instance, half dozen different sizes of "one inch board" and there is one species of wood that is sold under twenty different names.[120]

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[119] On the Division of Simplified Practice see Peri E. Arnold, "The 'Great Engineer' as Administrator: Herbert Hoover and Modern Bureaucracy," *The Review of Politics* 42 (1980): 342-343.

[120] Newspaper clipping, in Aubrey Drury Papers, box 14. For more examples on the activities of the Division of Simplified Practice see "Mr. Hoover's Dictionary," *Time*, June 18, 1923.

From this standpoint it would appear that he was unambiguously in favor of metrication—and many members of the pro-metric groups thought so[121]—as the metric system appear be a perfect solution to avoid having too many units of measurement. But Hoover, a trained engineer, did not consider that government mandates were the most effective way to attain standardization.

In a letter send to the First Pan American Standardization Conference, held in Lima, Peru in 1925, meant to be read in the inaugural session, Hoover outlined his hardcore beliefs on the issue of standardization, namely that standardization cannot be achieved through the imposition of arbitrary rules; to be effective laws and regulations ought to be based on agreements between all the parts and interests involved.[122] This philosophy was extended to metrology; Hoover attended multiple of the annual conferences on weights and measures held at the NBS, where he drove this point in numerous occasions, stressing that the government would help in the "voluntary adoption in commerce" of national specifications.[123] This dictum was a central part of the idea of an "associative state" that characterized Hoover political procedures, which consisted in

[121] See for example Melvil Dewey to Aubrey Drury, December 12, 1928, CU, Melvil Dewey Papers, box 66.

[122] Pan American Standardization Conference, *Primera Conferencia Panamericana para la Uniformidad de Especificaciones, reunida en Lima, Perú, del 23 de diciembre de 1924 al 6 de enero de 1925. Actas y demás documentación, publicación oficial* (Lima: E. Moreno, 1927), 93.

[123] See for example "Address by the Secretary of Commerce, Hon. Herbert Hoover," *Weights and Measures: Sixteenth Annual Conference of Representatives from Various States held at the Bureau of Standards* (Washington: Government Printing Office, 1923), 76-81.

having businesses cooperate with each other and with the government, giving priority to self-governing business associations.[124]

This style of government and the work of the Division of Simplified Practice were very successful in their standardization ambition for several industrial and commercial products; but it proved ineffective in the issue of securing a single system of measurement for the whole country, as the lack of agreement between industries made it difficult to find common ground.

In the previous chapter I detailed the problems that the lack of commitment of the federal government to push for a mandatory metrication policy created in the process of national unification of weights and measures. Hoover's policies are a perfect example of this, but he was not the first or the last to use this formula, it was part of much larger trend.[125]

Going back to the actors outside government who battled over the adoption of the metric system, during the 1910s and 1920s metric proponents made several new tries to advance numerous pieces of legislation, but every time the opposition was strong, obstinate, and, ultimately, victorious. Eventually these camps coalesced into formal associations.

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[124] David Hart, "Herbert Hoover's Last Laugh: The Enduring Significance of the 'Associative State,' " *Journal of Policy History* 10 (1998): 419-444.

[125] On some characteristics of this style of setting standards, see Andrew Russell, "The American System: A Schumpeterian History of Standardization," Progress & Freedom Foundation Progress on Point Paper 12, 2005.

Halsey and Dale—who had received financial backing from Brown & Sharpe Manufacturing Co.—organized in 1916 the American Institute of Weights and Measures, aimed to stop the metric advance and to “perfect” English measures.

That same year during the annual meeting of the American Association for the Advancement of Science a group of scientists and educators held the first meeting of the American Metric Association—with Italian educator Maria Montessori as an special speaker for the occasion.[126] The first president of the Association was the renowned mineralogist and vice-president of Tiffany and Co., George Kunz (who fruitfully mixed his knowledge on metrology and precious stones inventing the “metric carat,” that helped to standardize and simplify measurements in that field); Samuel Stratton (director of the NBS), was a member of the executive committee.

In 1919 Albert Herbert (the same who 20 years earlier championed the metric system with Andrew Carnegie in the Association of Manufacturers) hired Aubrey Drury, a professional advertiser, to operate the World Trade Club of San Francisco (later the All-American Standards Council) that promoted full national metrication—with special emphasis on facilitating commerce with countries from Latin America and the Pacific and to make American companies more competitive in those markets, vis-à-vis European industrial powers like Germany. Herbert also paid for a full-time representative in Washington to lobby his cause, W. Mortimer Crocker.

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[126] For access to a copy of the minutes of that first meeting of the American Metric Association (today US Metri Association): http://lamar.colostate.edu/~hillger/history.htm.

Even though he could not claim any expertise on metrology, Aubrey Drury became a relentless worker for the metric cause. His activity from 1920 to 1950 in several pro-metric civic organizations made him one of the key actors in the history of the metric movement in the United States (he served as director of the World Trade Club and its successor the All-American Standards Council; he also was Vice-President of the Metric Association). But despite the impact of his labor, he is little known and his papers and correspondence have been scarcely studied. It is complicated to estimate how many metric articles and news bulletins he wrote since 1919, as many of his pieces were sent unsigned to newspapers all around the country, but he should be counted among the most copious writers on the metric system ever (in the United States or otherwise). As he said about himself in a letter: "I have written more than 100,000 individual letters on the metric topic, besides sending out several million form letters and pamphlets, and have written also several million words in metric articles and publications."[127]

These groups wrestled in all imaginable settings: newspapers, popular magazines, technical journals, political campaigns, Congressional hearings, and, as we shall see, international conferences.[128]

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[127] Aubrey Drury to Karl E. Ettinger, not dated, Drury Papers, box 3.

[128] Just for a taste of this debates in the popular press, see Aubrey Drury "Modern Trade—Antiquated Tools: A Plea for International Commodity Quantity Standards in Trade and Industry," *The Rotarian* 26 (1925): 2: 29, 66-69, and the response by C. C. Stutz, "The Tools of Our Industry: Shall We Scrap Them?," *The Rotarian* 26 (1925): 6: 19, 87-91 (Stutz was secretary of the American Institute of Weights and Measures and member of the American Society of Mechanical Engineers). Also in that magazine, see the exchange between pro-metric Hilton Ira Jones (a chemist) and anti-metric Henry D. Sharpe (president of Brown & Sharpe Co.), in the editorial section A Debate-of-the-Month on "Adopt the Metric System?" *The Rotarian* 70 (April, 1927): 28-30.

Exporting a Fight: The Battle for Pan-American Uniformity

The clash between pro- and anti-metric associations stepped quickly to the international arena, primarily around the question of the economic integration of the Americas. A long battle was fought with and about Latin America around the issues of what system of measurement was better suited to bring unity to the "western hemisphere," what measures are actually used in the Spanish and Portuguese speaking countries, and whether the metric system was a suitable instrument to bring those countries together.

Halsey, Dale, Kunz, Drury, and the rest of the American disputants brought their fight south of the Rio Grande River, pretty much reiterating the same arguments, but revamped and adjusted to the continental circumstances. In the numerous Pan-American conferences dedicated to science, commerce, and standardization during the 1910s and 1920s the members of the Metric Association, the World Trade Club, and the American Institute of Weights and Measures made numerous appearances to present papers and to lobby representatives from other countries.[129]

This confrontation was critical because there was a genuine interest in the United States to have a more sizable influence in Latin America. Since the majority of the Latin American countries adopted the metric system during the second half of the nineteenth century this was a perfect opportunity for the metric camp to score some points showing how crucial the international arena was for the establishment of a system of weights and

[129] See for example the papers presented by Drury, the Metric Association, Dale, and W. R. Ingalss in one of the Pan American standardization meetings: Inter American High Commission, *Report of the Second Pan American Standardization Conference* (Washington: Government Printing Office, 1927), 75-87.

measures. In this they have the support of Americans working in the Pan-American Union itself, like William C. Wells—chief statistician of the Union—who insisted that world gradually was becoming one big market where the sale of manufactured products became increasingly more important than the sale of gross materials, and this required a common system of measures to produce standardized goods whose dimensions were the same in the manufacturing country as in the consumer's, and that system was the metric system.[130]

In this context the interest in Pan-Americanism was a door to pass metric legislation in America, as Halsey quickly recognized.[131] Faithful to his initial arguments, Halsey questioned whether the metric system was actually used by the people in Latin America and suggested that several systems of measurement coexisted there. To back up this opinion Halsey sent questionnaires to selected people in South American countries asking them about what units of measurement were used for international and domestic commerce in their place of residence. With that information he prepared a report that allegedly demonstrated the failure to introduce the meter, liter and kilogram as exclusive

[130] William Wells, "The Metric System from the Pan-American Standpoint," *The Scientific Monthly* 4 (1917): 196-202.

[131] "To Star New Fight on Metric System: Manufacturers See Insidious Move to Make It a Feature in Pan-Americanism," *New York Times,* March 30, 1916.

units of measurement.[132] Another study, this time by the metric proponents, had to be prepared to counter this suggestion.[133]

In 1919, during the Second Pan-American Conference, the president of the American Metric Association presented a paper on "The Metric System as a Factor in Pan American Unity," in which he advocated for the metric system and for the introduction of a common continental currency. Kunz maintained there that "nothing can better pave the way for a good understanding among the American nations than uniformity of currency and of weights and measures, for this will obviate many causes of misunderstanding and dispute, and will aid powerfully in developing trade among these nations."[134]

In that same occasion Halsey advocated for a plan to standardize the units of the customary English measures with the Spanish colonial measures (with the former as standard to the latter, of course) and to use that system in all the Americas as a real Pan-American system of measurement (this plan was based on some similarities between some units in those systems). In an interesting historical and genealogical move, Halsey

[132] Frederick A. Halsey, *The Weights and Measures of Latin America* (New York: American Society of Mechanical Engineers, 1918).

[133] "The Weights and Measures of Latin America," *Decimal Educator* 2 (1919-1920): 178-186, 218-219, 259.

[134] George Kunz, "The Metric System as a Factor in Pan American Unity," in *Report of the Second Pan American Conference: Pan American Commerce; Past, Present, Future from the Pan American Viewpoint*, ed. John Barret (Washington: Pan American Union, 1919): 270. See also George Kunz, "The International Language of Weights and Measures," *The Scientific Monthly* 4 (1917): 215-219. In a letter to Melvil Dewey Kunz drew a succinct explanation on his view on measurement and international languages: "Has it ever occurred to you that musicians in every part of the world can read and play the music written by anybody in the civilized world? Why not the meter-liter-gram?" (George Kunz to Melvil Dewey, December 18, 1924, Melvil Dewey Papers, box 66).

proclaimed "Let us unify the weights and measures of the two Americas and the British Empire on the basis of the system which came to us from the mother of us all—the Roman Empire."[135]

This movement served Halsey and Dale as a counterpunch to the internationalistic pretensions of the metric camp, and theoretically speaking it sounded plausible. The three centuries of Spanish dominance in the New World created something close to a Hispanic-American system of measurement, with virtually all countries from Chile to Mexico sharing a considerable number of units (vara, carga, fanega, libra, onza, cuartillo among them)—even if this was an imperfect "system" from the standpoint of uniformity and standardization, due to the high variability in the magnitudes of those units between and within countries.

Halsey, Dale and their anti-metric associates used the existence of this apparent Ibero-American unity, along with its similarities with the English system, to recommend an alternative Pan-American system of measures—which basically meant the adoption in Latin America of the English units calling them the Spanish names: pound-*libra*, ounce-*onza*, yard-*vara* and so forth. But this plan was, for all practical matters, intended solely to influence the metrication debate in the United States. The actual situation in Latin America was never a serious concern for them. Their objective was exclusively stopping the penetration of the metric system in the United States. Halsey and Dale never engaged in significant conversations with Latin American experts and governments—they usually

[135] Frederick A. Halsey, "Pan Americanism in Weights and Measures," in *Report of the Second Pan American Conference: Pan American Commerce*, ed. John Barret (Washington: Pan American Union, 1919), 274.

were more enthusiastic to receive attention from other English-speaking countries than from people in Latin America.

Also, unfortunately for Halsey and Dale, their Pan-American plan arrived too late. By the 1920s Latin-American countries had already invested a lot of time and money to advance the introduction of the metric system to seriously consider starting a new plan of standardization. New because Dale's plan was not a simple "get back to where you once belong," as it may look. It implied rather to unify all units of measures according to physical standards that besides the names were only randomly used. At the end it represented wasting all the efforts invested in the metric system and starting again from scratch. Not surprisingly the plan was no taken seriously by any government or interest group in the continent. What Latin American representatives sought was *metric* continental unification, and were much more interested in listening to the plans advanced by Drury and company.[136]

Thus despite Dale and Halsey's candor Latin Americans did not receive well the idea of a non-metric basis for Pan-American metrological unity. For example, in response to the paper "Uniformity or Confusion in Pan America?" presented by Samuel Dale in the First Pan American Standardization Conference in Lima, Peru, (where he reinstated the argument that the metric system only introduced confusion in commercial transactions and that it would be better to standardize the different pounds and inches in the

[136] On Drury's plan for continental metrological unification, see Aubrey Drury, *Un mismo sistema de pesas y medidas para toda la América* (Washington: La Unión Panamericana, 1927); Aubrey Drury, *One Standard for All America* ([San Francisco]: American Standards Council, [1927]); also of interest is Aubrey Drury, "Making this World Metric," *Pan Pacific: A Magazine of International Commerce,* June 20 (1920): 84-85.

continent), a member of the Sociedad Nacional Agraria of Peru replied saying that Latin American countries were well on their way to metric uniformity and that it would be better for the United States to go metric.[137]

The same message came again and again from Latin America, with key actors from different countries voicing their disappointment over the United States not making good on its pledge, made in 1890, to join the other American countries in the use of the metric system—something that hurt their common business interests. For example in 1927 the Secretary of the Ministry of Industry of Colombia wrote to the Aubrey Drury saying:

> The United States are proud of the large amount of out-of-date machinery that they discard to be replaced with more efficient equipment as soon as a practical innovation appears—without considerations of expense. A scientific and uniform system of weights and measures is a vital equipment for domestic and international commerce. Abandoning the antiquated and incoherent system inherited from colonial times is worth as much as throwing away dated machinery. Adopting the French metric system would be a convenient and lucrative achievement, worth of such a great people; it would create a bridge to the other American republics and enhance their commerce with them.[138]

Regarding the case of Mexico, merchants, bankers, and diplomats all received information that also contradicted Halsey's and Dale's claims on the prevalence of customary measures and metrological confusion. At least regarding foreign commerce,

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[137] Samuel S. Dale, "Uniformity or Confusion in Pan America?" and a letter by A. F. Del Solar to the First Pan American Standardization Conference, December 19, 1924. Melvil Dewey Papers, box 67.

[138] From Ministry of Industry, Colombia to Aubrey Drury, November 5, 1927 (Aubrey Drury Papers, box 3).

Mexico had become a metric nation. For example, this what the US Vice-consul at Ciudad Porfirio Díaz (today Piedras Negras), on the Mexican-American border, reported:

> The metric system is the legal standard for weights and measures in the Republic of Mexico. Our English weights and measures are stumbling-blocks to the Latin countries whose trade we seek. The persistent use by our merchants in their catalogues, circulars, etc., of our old English weights and measures causes us to lose considerable trade with Mexico and other Latin-American countries, as they are unintelligible to many foreign buyers. It would be well for our merchants and manufacturers desiring to extend their trade to Mexico and other countries using the metric system to base descriptions of their goods and estimate prices upon this system.[139]

And this is what John Lind, personal representative of President Woodrow Wilson in Mexico, commented on this same topic:

> We must get into line with the commercial world in the matter of weights and measures. I asked an intelligent German merchant in Vera Cruz one day to explain to me how it had come about that Germany had absorbed so much of the trade that at one time went to England. He reached into a drawer, pulled out an invoice from England and said, "Do you see those denominations or yards, feet and inches, gallons and pints, two kinds of ounces, grains and pennyweights, the whole summed up in pounds, shillings and pence? Well," he continued, "a Mexican, even if he can read a little English, needs an interpreter and an accountant to put this into the language of civilization." […] We should be in accord not only with Latin America, but with all the rest of civilization, except England. The American manufacturer and merchant must learn to understand that a foreign market is always a 'buyers' market."[140]

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[139] Quoted in *Hearings Before the Committee, Feb. 6-March 3, 1902, on Bill H. R. 2054* (Washington: Government Printing Office, 1902), 163.

[140] John Lind, *The Mexican People* (Minneapolis: The Bellman, n.d.), 29-30. A similar case, but in Bolivia, is described in Hilton Ira Jones, "Why not Now?," *School Science and Mathematics* 19 (1919): 512.

In 1926 a more emphatic call of attention to the necessity of using the metric system in Mexico came from within, when the Mexican Confederation of Chambers of Commerce, following an initiative by the Chamber of Commerce of the border state of Chihuahua, made a call for the "urgent necessity to use the metric system." They expressed their disappointment with the United States' and England's refusal to adopt the metric system, noting that the adoption "would help them tremendously in their domestic dealings, it would bring immensely positive results to improve their relationship with clients all over the world, and they would also collaborate with the establishment of universality in weights and measures."[141] The document recalled that the United States had participated in the 1890 agreement for Pan-American metrication. Finally, the Confederation asked for its American and British counterparts to take steps towards metrication.

Overall, the reluctance by the United States to adopt the metric system generated shock and dissatisfaction in Mexico and other Latin American countries, where the United States was seen by many as an advanced nation and their hope-to-be future; its unwillingness to implement the metric system was considered as a weird anomaly—it was certainly something that did not match with their image of a prosperous nation. At the end, as we know, all exhortations—within and outside America—to persuade the government and major economic actors to embrace the metric system were not enough to prompt any substantial action.

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[141] Confederación de Cámaras de Comercio de los Estados Unidos Mexicanos, "Urgente necesidad de hacer universal el uso del sistema métrico decimal. Estudio para la 9na. Asamblea General de Cámaras de Comercio de la República. Septiembre de 1926." CU, Aubrey Drury Papers, box 3.

The American government recognized the importance of the metric system to enhance the commercial relations of the country, but that was insufficient to convince them of the necessity to pursue a drastic metrication policy. Illustrative of this is a letter by Lyman J. Briggs (director NBS) to J. T. Johnson (president of the Metric Association) in 1943:

> There is no question but that we should cooperate to the fullest extent with the Latin American countries and should promote trade with them. But there is a serious question as to whether it is either necessary or desirable for this country to adopt the metric system in order to use it in foreign trade. A knowledge and understanding of the metric system and a willingness to use it properly are essential. No one proposes that we should change our language to Spanish or Portuguese in order to promote trade relations with Latin America because in the matter of language it is recognized that knowledge and understanding are the essential items. Perhaps the analogy is not complete but the idea deserves consideration. If the metric system is a sufficient step forward, then its use in our trade with our neighbors to the South may give it the impulse for use among ourselves.[142]

That impulse never came about, and for the rest of the twentieth century the obstacles in the road to metrication in the United States proved insurmountable—as they had been in the past.

North American Free Trade and Metrological Cooperation

During the late twentieth century, international cooperation and the ambitions of

[142] Lyman J. Briggs to J. T. Johnson, April 9, 1943 (a copy of the letter was sent to the Vice President of the United States, Henry A. Wallace). CU, Aubrey Drury Paper, box 3.

free trade in the Americas continued to influence the development of metrology and the administration of the metric system. In fact, the old longing of the first Pan-American Conference in 1890 of unifying weights and measures in the continent, got materialized decades later, in a way, with the help of the Organization of American States (OAS)—which itself can trace its origins to the 1890 meeting in Washington. This time the aim was not the establishment of a single system of weights and measures for all the American countries, but the creation of a coordinating body. Interested in solving technical and legal problems linked to the production processes, the OAS started in 1974 a special project on a regional system for metrology and calibration (known as Sistema Interamericano de Metrología y Calibración, SIMYC), which included ten Latin American countries and was supported by the National Bureau of Standards.[143] This served as the basis for the Inter-American Metrology System (SIM), created in 1979. The objectives of the SIM are the definition of the national measurement system in each country, compatibility in measurement results, training of technical personnel, distribution of scientific information, and collaboration with other international bodies—mainly the General Conference on Weights and Measures. The SIM also tries to help international economic integration and free trade by reducing technical barriers between countries and the promotion of programs of technical cooperation in metrology and standardization.[144]

[143] The National Bureau of Standards changed its name to National Institute of Standards and Technology in 1988.

[144] *Carta Metrológica* 2 (1980): 7-21.

The creation of the OAS and renewed plans of free trade in the Americas played also an important role in the development of new technical institutions devoted to measurement in Mexico. During the negotiations of the North American Free Trade Agreement (NAFTA) in the late 1980s and early 1990s, it was stipulated that participating countries should have frameworks for intellectual property protection and effective systems of standards and metrology (the coincidence in these ideas with the stated goals of the First International Conference of American States is no accident). Ultimately, these requirements forced the Mexican government to support the creation of the Centro Nacional de Metrología (CENAM), which today holds the national measurement standards (among them the aforementioned kilogram number 21 acquired from the International Bureau of Weights and Measures in 1891).[145]

A number of Mexican scientists and engineers had worked for many years trying to establish a metrological center in Mexico, but never received assistance from the government to complete the project. It was with the negotiation of NAFTA that they found a favorable situation to get that support as the CENAM would be that metrological center that Mexico needed to enter into the Treaty.[146] All the pieces fell into place in 1992, when the institution of the CENAM was legally formalized—in December of the same year, Mexico, Canada and the United States finally signed the Free Trade

[145] Significantly, one of the mottos of the CENAM is "For the competitiveness of the Mexican Industry," stressing the economic character of this technical institution.

[146] Financial and technical support for the creation of the CENAM also came from the Organization of American States and the Physikalisch-Technische Bundesanstalt (the German institute for science and technology for the field of metrology, that also help some other Latin American countries to found their respective metrological centers). Information provided by Héctor Nava Jaimes, director of the CENAM (interview July 7, 2006).

Agreement.[147] Coming full circle, it was the plan for a Pan-American commerce agreement that gave prominence to a federal office at the end of the nineteenth century; and it was a North-American free trade treaty that reinvented that agency at the end of the twentieth century.

FINAL COMMENTS

What have been the consequences of not adopting the metric system for the United States economy? It is difficult to quantify. An estimate made at the beginning of the present century said that it represented more than two billion dollars of lost opportunities for non-metric American industries.[148] To this we have to add all the extra expenditure that metric American industries have by doubling some production processes (like slight changes in same car models, one for the United States and another with metric specifications for Europe). Is this a validation of the claims of pro-metric groups about the necessity for the United States to go metric? Just partially.

Frederick Halsey said at the dawn of the twentieth century that foreign commerce does not require the adoption of a new system of measurement in manufacturing. Probably he was right—at least in the case of the United States. American industries have been a global force for more than a century now. Working from that position of power they were in the position to wait for the world to adopt their standards, instead of the

[147] The Treaty went into effect in January 1, 1994.

[148] Louis Jourdan, *La grande métrication* (Nice: France Europe éditions, 2002), 166. Jourdan mentions the *Wall Street Journal* as the source of that figure, but unfortunately does not quotes an article or date in particular.

other way around. But this was a luxury that only a very powerful country could afford (as England did in the nineteenth century). For countries like Mexico, however, that was simply not a feasible option. Some dictate the rules, others follow them.

Will a greatly globalized economy and a decline in American hegemony change this situation? Some think so. See for example this recent comment by a mass media political commentator:

> To bring others into this world, the United States needs to make its own commitment to the system clear. So far, America has been able to have it both ways. It is the global rule-maker but doesn't always play by the rules. And forget about standards created by others. Only three countries in the world don't use the metric system—Liberia, Myanmar, and the United States. For America to continue to lead the world, we will have to first join it.[149]

This of course sounds theoretically possible. I am skeptical, though. As it was stressed in the previous chapter, the change to the metric system requires forceful intervention by the state—the absence of which has ultimately crippled all tries to metricate the United States—but it does not look that the American state has now the strength to muster such an effort. A radical change in the economic position of the United States in the world or a substantial transformation in the structure of the federal state appear to be necessary for the metric system to have a realistic chance to set foot in this territory.

Finally, there is another important lesson that can be learned from what I have shown in this chapter. The case of international currency can serve to illuminate an

[149] Fareed Zakaria, "The Rise of the Rest," *Newsweek*, May 12, 2008. Note that Zakaria miscounts the number of non-metric countries in the world, which are actually seven, as I showed in chapter 2.

important aspect of the metric system global triumph. Since there was no other "modern" or "scientific" plan able to seriously challenge the metric system, people in different countries and from different professions interested in a radical metrological reform were galvanized around a single project, instead of being divided among themselves in discussions about the virtues and defects of every single hypothetical plan. For better or worse, the metric is what they have, and this lack of options gave them greater solidarity. When the suggestive but controversial idea of an international currency was discussed, experts and politicians were divided among the many possible ways to materialize the idea, and that weakened their position significantly.[150]

[150] This makes the failure of the multiple systems invented to challenge the metric system very relevant to explain why the metric system was successful—as I will show in the next chapter.

CHAPTER IV

Scientists and the Struggle for the Metric System

> There are certain ideas of uniformity, which sometimes strike great geniuses (for they even affected Charlemagne), but infallibly make an impression on little souls. They discover therein a kind of perfection, which they recognize because it is impossible for them not to see it; the same authorized weights, the same measures in trade, the same laws in the state, the same religion in all its parts. But is this always right and without exception? Is the evil of changing constantly less than that of suffering? And does not a greatness of genius consist rather in distinguishing between those cases in which uniformity is requisite, and those in which there is a necessity for differences? In China the Chinese are governed by the Chinese ceremonial and the Tartars by theirs; and yet there is no nation in the world that aims so much at tranquillity. If the people observe the laws, what signifies it whether these laws are the same?[1]
>
> *Montesquieu*

> The measurers include all of us. A full list would name every human art and craft. It is an army with world-wide front for mastery of nature and its countless possibilities. Measurement is the weapon, strategy, and tool of conquest; the password to the citadel of truth. To measure is to conquer.[2]
>
> *Henry D. Hubbard.*

> We cannot break completely with the past, because not only must we take account of public repugnance, but scientists themselves have a tradition to which they remain tide.[3]
>
> *Henri Poincaré*

This chapter examines the role of scientists, intellectuals, and educators in the campaigns and implementation of the metric system in the United States and Mexico.

[1] "Of the Ideas of Uniformity," *The Spirit of Laws* (Book XXIX, Of the Manner of Composing Laws).

[2] Henry D. Hubbard, "Measurements of Tomorrow," talk at the Summer Meeting of the Metric Association, Friday, June 24, 1927.

[3] Quoted in Peter Galison, *Einstein's Clocks, Poincare's Maps: Empires of Time* (New York: Norton, 2003), 165.

First there is an analysis of the debates among the Mexican intelligentsia during the nineteenth century over the pertinence of adopting the metric system, with a group of influential intellectuals pushing for metrication and others arguing in favor of updating (on a scientific basis) the units of measurement inherited from the colony. Secondly, I trace a portrait of a *typical* pro-metric intellectual in nineteenth-century America, the educator and celebrated librarian Melvil Dewey, the founder of the first voluntary organization devoted to impulse metrication in the country, the American Metric Bureau. The chapter then moves to the figures Hebert Spencer and Lord Kelvin, whose debate over metrication at the turn of the nineteenth century reshaped the content of the discussions over metrological reform at both sides of the Atlantic. Finally there is a consideration of the confrontation between the decimal metric system and its modern competitors.

1. THE METRIC SYSTEM AND THE INTELLECTUAL COMMUNITY IN MEXICO

The metric system was created by scientists—though not exclusively for scientists—and scientists have been key actors for its insertion in many countries, including Mexico, where several anti- and pro-metric figures were important actors in the intellectual history of the country.

It is not clear how the first news about the metric system arrived to what was then the viceroyalty of New Spain, but there are two conspicuous options. One is the Spanish-Mexican chemist and naturalist Andrés Manuel del Río, who arrived to the Americas in

1794, sent by the Spanish crown to work in the Real Seminario de Minería (School of Mines) to aid the mining industry in the colony. But before he traveled to the new world, Del Río visited Germany and France to learn from some of the most important scientists of the time. In Germany he met geologist Abraham Gottlob Werner and polymath Alexander von Humboldt.

In Paris Del Río studied with Lavoisier in his laboratory, at the time when Lavoisier was making the experiments and calculations to define the first prototype of mass for the metric system, the kilogram.[4] It is not a stretch to assume that Del Río was aware of Lavoisier's metric experiments and that he knew how the system worked. Besides, Del Río also collaborated in Paris with the renowned mineralogist René Just Haüy, who also cooperated with Lavoisier during that time in the specification of the kilogram.

In 1793 Lavoisier was sent to prison and later killed in the guillotine on May 8, 1794. Allegedly when his head fell down people watching cried "The revolution does not need scientists!" Some biographers of Del Río have argued that he had to flee France disguised as a water-carrier through isolated roads to avoid persecution from the "terrorists."[5] Somehow he managed to reach Calais and take a ship to England before getting to Spain. Soon later he was in New Spain. There he became a crucial figure in the development of science in nascent Mexico (a country that he later adopted as his own).

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[4] On Lavoisier and the metric system: Jean-Pierre Poirier, *Lavoisier: Chemist, Biologist, Economist* (Philadelphia: University of Pennsylvania Press, 1998), 319-324.

[5] Arturo Arnáiz Fred, *Andrés Manuel del Río* (Mexico: Casino Español de México, 1936).1

Considering his ample connections with the scientific world in Europe and the Unites States, it seems safe to assume that he was proficient in using metric measures; however, he did not use them in his own research (or at least he did not employ them in his books and published papers), as he stuck with the old *pies* and *pulgadas*.[6]

The other option of how the metric system arrived to the New Spain is Humboldt himself. A few months before his famous travel to the Americas in 1799, Humboldt visited Lalande, Delambre, and other French savants who were conducting some of the final field calculations for the measurement of the meridian needed to determine the meter.[7] We know for sure that Humboldt made many of his calculations in the Americas using meters for linear measures, and the centigrade scale for temperature.[8] In the New Spain, in 1803, Humboldt contrasted the standard of the Mexican *vara* with the meter (According to Humboldt's measurement the *vara* was 816.16 millimeters long.).

Anyhow, the metric system reached the New Spain; and did not take long for the local elite to familiarize themselves with it.

In the second half of nineteenth century numerous engineers, astronomers, and geologists that took part in the efforts to introduce the metric system were also involved

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[6] See for example, Andrés Manuel del Río, *Elementos de orictognosia* (Mexico: Don Mariano Joseph de Zúliga y Ontieros, 1795), 37, 74, 95, 122; and *Tablas mineralógicas dispuestas según los descubrimientos más recientes é ilustradas con notas* (Mexico: Don Mariano Joseph de Zúliga y Ontieros, 1804), 70, 86.

[7] Humboldt to Baron de Zach, June 3, 1798, in Alexander von Humboldt, *Lettres américaines d'Alexandre de Humboldt* (Paris: E. Guilmoto, 1905), 2-4; Ken Alder, *The Measure of all Things* (New York: The Free Press, 2002), 217-219

[8] As Humboldt pointed out: "Il sera utile d'observer que dans tout le cours de cet ouvrage, partout où le contraire n'est pas indiqué, on s'est servi du thermomètre centigrade et de la mesure linéaire du mètre, mais de l'ancienne division du temps et des degrés de latitude," Alexander von Humboldt, *Essai sur la géographie des plantes: accompagné d'un tableau physique des régions équinoxiales* (Paris: Chez Levrault, Schoell et Compagnie, 1805), 47.

in a number of crucial state-sponsored projects such as the Comisión de Límites de México y Estados Unidos (in charge of defining the borderline between Mexico and the United States after the Mexican-American war); in cartographic tasks like determining the precise location of several cities of the country, the creation of the geographic map of the valley of Mexico (in the Dirección General para la Formación del Mapa Geográfico del Valle de México), the making of the *Carta geográfica de la república*, the drainage system of Mexico city, the creation of the National Astronomical Observatory and the Escuela Nacional Preparatoria, and participated in the Comisión Astronómica Mexicana al Japón para Observar el Tránsito del Planeta Venus (assembled to observe the transit of Venus across the Sun in 1874). This was a group that actively participated in the national life and worked in key institutions for providing technical and scientific knowledge to the archaic Mexican state.

These experts were mainly grouped in two strategic institutions: the Sociedad Mexicana de Geografía y Estadística (SMGE),[9] and the Ministry of Development. Scientists like Benigno Bustamante, Francisco Díaz Covarrubias, Francisco Jiménez, and Manuel Fernández Leal, among others, played key roles in generating many the technical knowledge necessary for the transition from the old system of weights and measures to the metric system. Fernández Leal was especially important, as he was in charge of the

[9] On the importance of the SMGE for the nineteenth-century Mexican state see María Lozano Meza, "La Sociedad Mexicana de Geografía y Estadística (1833-1867) su relación con el estado," in *Memorias del primer congreso mexicano de historia de la ciencia y la tecnología* (Mexico: Sociedad Mexicana de Historia de la Ciencia y de la Tecnología, 1989), 833-840.

Ministry of Development during the government of Porfirio Díaz, a crucial period in the effective implementation of the metrical system (as I showed in chapter two).

But before the actual implementation of the system was ordered, these men of knowledge had to confront some of their colleagues in what was an impassioned debate over the pertinence of going metric.

Radical Change or Servile Adoption?

Since 1849 there were serious discussions in the Mexican government about the possibility of implementing what they called the "French metric system," and to make it the only legal system in the country. An *ad hoc* committee was formed at the House of Representatives to explore that possibility and drafts of bills were proposed to carry out the metrological transition. However, passing those laws never came to fruition, even though the topic arouse considerable interest—never free of strong arguments and questionings.[10]

Three years later a special commission was formed in the SMGE in order to design a plan for the creation of a system to regulate all weights, measures, and currency in the country. The SMGE had already received in 1849 a precise standard of the meter as a gift from a French diplomat. The labors of the commission were hindered as many projects and counterproposals were submitted for discussion. In 1853 Joaquín Velázquez de León—head of the newly created Ministerio de Fomento, Colonización, Industria y

[10] See *El Siglo Diez y Nueve,* February 22 and April 22, 1849.

Comercio (Ministry of Development)—sent to the SMGE a metrication plan, prepared by Luis Jáuregui, recommending its consideration among the works that had already been done by the commission. This led to the establishment of a second commission (formed by Leopoldo Río de la Loza, Cayetano Moro, and José Joaquín Pesado), and whose works concluded at the submission of a report in which they recommended the adoption of the metric system.[11]

This suggestion generated intense debates within the scientific comunity.[12] Founding members of the SMGE, like José Justo Gómez de la Cortina (better known as Conde de la Cortina) and Benigno Bustamante, presented articles voicing their disapproval to use the metric system as the remedy to unify weights and measures (a debate that nowadays may seem idle, because we find the metric system simple and we know that it is used all over the world, but in mid-nineteenth century there were no obvious reasons for choosing the metric system over other systems, mainly because its real internationalization was incipient). The general lines of these controversies can be illustrated in the writings that Bustamante and Cayetano Moro presented in the SMGE's *Boletín* in 1852.[13]

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[11] Miguel J. Arroyo, "Segunda reseña que presenta a la Sociedad Mexicana de Geografía y Estadística," *Boletín de la Sociedad Mexicana de Geografía y Estadística* 4 (1854), 340. For the recommendations made by the commission, *El Siglo Diez y Nueve,* September 8, 1854.

[12] See *El Siglo Diez y Nueve* April 3, 1853; August 14, 1854; and November 2, 1854.

[13] Benigno Bustamante, "Artículo sobre los fundamentos en que debe apoyarse el arreglo definitivo y general de los pesos y medidas más convenientes en la república mexicana," *Boletín de la Sociedad Mexicana de Geografía y Estadística* 3 (1852): 45-52; and in that same volumen, Benigno Bustamante, "Contestación a las observaciones relativas a la medida que se propuso como unidad para arreglar definitivamente la vara mexicana," 56-63, and Cayetano Moro, "Observaciones sobre la medida que se propone sustituir a la vara mexicana," 53-55.

Benigno Bustamante, one of the most tenacious and brilliant opponents of metrication in the country, was a well-known mathematician and geographer, member of the geographical societies of Paris and New York. He authored several works on botany and cartography, and built a modified theodolite (called "Bustamantino," after him). In his long political and military career, he had fought in the defense of the historic "alhóndiga de Granaditas," and was among the first to recognize the Declaration of Independence of the Mexican Empire in 1821. His was an opinion that could not be ignored, and his anti-metric standing meant that the commission on weights and measures was not able to present a unanimous report. Bustamante's rival, Cayetano Moro, led in 1842 the scientific commission to explore the Isthmus of Tehuantepec ordered to facilitate interoceanic communication. Since 1849 Moro was a persistent advocate of the adoption of the meter.

Bustamante's article in the *Boletín* underlined that in order to fix the metrological chaos in Mexico it would be more fruitful to determine more accurately the *vara mexicana* (Mexican yard), which was already the official standard, instead of adopting the metric system, which, he insisted, represented too drastic a change for people's customs. If the Mexican *vara* was determined on reference to the Earth's meridian quadrant, it would be based on nature itself and would be then as accurate as the meter itself. According to this plan, if the meter was the ten-millionth of the of the distance from the equator to the north pole, the Mexican *vara* would be "the twelve-millionth of that quadrant" (the definition of the meter was the tenth-millionth of that quadrant).

To justify his plan Bustamante based his arguments on postulates made by the

Spanish mathematician and military engineer Gabriel Ciscar y Ciscar (although, ironically, Ciscar was one of the earliest supporters of the metric system).[14] What did Bustamante argue against the adoption of the metric system? Amongst other things he said that given that the meter itself is

> around one sixth greater than the current vara—and beyond the frequent opposition that this considerable difference in size would produce—it would create significant inconveniences in small retailing operations, in farming transactions, and, above all, in mining possessions [...] for even though this difference would be well known, it will lend itself to misunderstandings, disputes, and quarrels between neighbors, and the subsequent halting of productive businesses.[15]

Thus, if the Mexican *vara* were in concert with nature—meaning, if it were calculated as a fixed fraction of the meridian, like the meter—it would be a solution with

> All the advantages that French set upon gaining from the meter, without the inconveniences that the servile adoption of the meter would bring to us; even if things are very good by themselves, it is convenient to modify them according to the local circumstances in order to produce positive outcomes.[16]

Bustamante's idea appeared to be as an ideal solution: it served one of the main

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[14] Ciscas, as I mentioned before, was one of Spain's representatives to the Congress on Definitive Metric Standards in Paris, 1799, see Juan Francisco López Sánchez y Manuel Valera Candel, "Gabriel Ciscar en el congreso de unificación de pesas y medidas de País de 1798," *Asclepio: Revista de Historia de la Medicina y de la Ciencia* 46 (1994): 3-35; Leonardo Villena, "The Role of Spanish Navymen and Military Engineers in International Metrology," *Acta Metrologiae Historicae* II (1989): 266-270; José Ramón Gómez Martínez, María Teresa Sánchez Trujillano y José Antonio Tirado Martínez. *¿Y esto en onzas cuánto es?: 1853-2003, 150 Aniversario de la implantación del Sistema Métrico Decimal* (Logroño: La Rioja, 2003), 15, 55; and Juan Gutiérrez Cuadrado, *Metro y kilo: el sistema métrico decimal en España* (Madrid: Akal, 1997).

[15] Bustamante, "Artículo sobre los fundamentos," 51.

[16] Bustamante, "Artículo sobre los fundamentos," 51.

needs sought after by reformers—that the units of measurement were in accord with nature—and, at the same time, it avoided the multiple complications derived from breaking radically with customary measures. In other words, the plan to have a Mexican *vara* based in geodesic measures was a way of having a "scientific unit of measure" with *universal validity*, while keeping a *national measure*.

Those in favor of the metric system were aware of the dangers that a drastic innovation would bring. Moro, in his reply to Bustamante, conceded that "a change in the system of weights and measures must necessarily upset rooted ideas and habits; and it is therefore natural that it will not be admitted without repulsion."[17] Nonetheless Moro considered that in spite of that obstacle, it would be far easier to change the measurement system altogether with a new one than adding a new *vara* to all those already in use across the country, something that would bring additional puzzlement. As he put it, "the new unit of measurement should be so different in relation to the old one that there will be no chance for confusion."

Moro maintained that adopting the metric system would be a definite solution to the problem of weights and measures, as it was a system known worldwide, which had been already officially adopted by several countries (at the time that meant nations like Belgium, Switzerland, and Piamonte), it was already employed in certain national industries in Mexico (like arsenals and foundries), and it had become the established measurement language in science. Moreover, its introduction, Moro concluded

[17] Moro, "Observaciones sobre la medida," 53.

optimistically, would not be complicated.

In hindsight, we can point out—with the advantage of seeing things a century and a half later—the hits and misses of these contending parties. Those opposing metrication were right in thinking that the change in metrological systems would entail a monumental effort and that the population at large would be adamant in clinging to customary measures. Those advocating for metrication rightly predicted that the metric system would be used all over the world, even though they miscalculated the amount effort needed to eradicate the measures that had been used by regular people for centuries and to impose the new ones.

Opponents of the metric system usually have had a more developed "sociological sensitivity" than metric supporters. Antagonists have been more aware of the hurdles of changing an entire measurement system and have been more aware of the popular objections to such a change. Pro-metric advocates, on the other hand, have been most of the time naïve about how much money, time, and man-power is needed to carry on a full metrication program at a national scope. Time has ultimately prove the pro-metric group right, and large scale metrication has indeed been achieved; but experience has also shown that the pessimistic view of anti-metric parties was justified due to the tremendous amount of toil that was required to actually transform millions of laymen into metric users.

Civilized Standards, Civilizing Measures

In order to understand the decimal metric system and what it meant for the politicians, bureaucrats, and men of knowledge who made possible its adoption, it is not enough to accentuate the multiple practical benefits that metrication brought to public administration, commerce, and scientific communication; it is necessary as well to appreciate that for many metric promoters the metric system was a symbol of something bigger.

Since mid-nineteenth century almost every single public proposal or piece of legislation advocating for the introduction of the metric system was framed under the broad but powerful idea of *civilization.* It was common for Mexican elites of the second half of the century to express the aspiration to see Mexico becoming part of the "civilized nations." This was a sort of imaginary club of countries, defined around the idea of civilization, where reason, science, industry, cosmopolitanism, and other ideals were amalgamated. Civilization—sometimes conceived as a goal line that had to be reached, as a condition that is gained by acquiring specific attributes, or as a state that is gradually attained—was affixed to the metric system. The metric system was part of the imagery of civilization—the meter was seen as brought about by enlightened people in a leading scientific nation—and it was also seen as a *civilizing* agent, an instrument that would promote the enlightening of the masses. Being metric was one of the traits that distinguished civilized nations, an item in the list of requirements to be accepted into the club.

Then, for example, during the short-lived reign of Maximilian I, in the opening lines of the Minister of Development annual report it was claimed that "One of the urgent necessities demanded by the state of civilization to which our country has arrived is the establishment of the decimal metric system."[18] This kind of rhetoric lived for several decades. During the Díaz regime the metric system was presented in government publications as a rational and scientific creation, worthy of praise not only for its technical qualities but because of it was employed by the "civilized nations."

That is how the metric system was advertised in pamphlets, handbooks, and manuals sponsored by the Ministry of Development and local governments to instruct the general population about the new measurement system and to teach them how to use it in daily activities. These leaflets and brochures were drafted by engineers from the state capitals and usually included conversion charts between metric and customary measures.

During the 1890s many of this state-sponsored pro-metric literature, half-pedagogic, half-propaganda, was an answer by the state governors to a call made by Manuel Fernández Leal, Minister of Development, six months before the weights and measures law of 1895 became effective. That call shows the tone and vocabulary used to endorse the metric system:

> Improvement in the means of communication brings, as a necessary consequence, development in commercial trade, both material and intellectual, among civilized peoples. This development is eminently beneficial for the countries that exchange products and ideas; strengthening this development is a duty of all governments. A great parasite for this *civilizing change* is the imperfection of the current weights and measures systems used in each country; a parasite clearly identified since the end of last century by an intense and sustained sentiment of universal renovation. The French Convention

[18] *Memoria presentada a S. M. el Emperador por el Ministro de Fomento Luis Robles Pezuela de los trabajos ejecutados en su ramo el ano de 1865* (Mexico: Imprenta de J. M. Andrade y F. Escalante, 1866), 3.

> received the glory of bringing to fruition a reform of weights and measure worthy of fanfare and admiration; a reform with scientific bases and in accord with a number system stable and universally accepted.[19]

In the communication Fernández Leal asked governors to double their efforts in order to secure the proper observance of the new metric legislation since day one. He ended his communiqué emphasizing that the federal government counted on the "enlightenment and patriotism" of each state to fulfill the obligations that the law imposed on them regarding the definite implantation of the metric system, "which is already claimed by public interest to promote the intellectual and material development of the nation."[20]

In return, several governors responded asking experts from their own states to publish texts that could enlighten the local folk on the virtues that metric measures would bring. A glimpse into some of these pamphlets shows some of the values that the scientific and political elites bestowed into the metric system; values that they wanted to endorse to persuade common people about the benefits of the coming metrological change. For example, see this contribution by an engineer from the state of Queretaro in 1896:

> On September 16th of the current year a new law will rule, it lays the use of the decimal metric system, a breakthrough innovation for commerce, as it homogenizes weights and measures in all signing nations of the Meter Convention, that will smooth out commercial

[19] Secretaría de Fomento, "Circular sobre pesas y medidas," March 16, 1896, AGN, Pesas y medidas, box 10, exp. 1. Emphasis added.

[20] AGN, Pesas y medidas, box 10, exp. 1.

relations and will aid the general public with a clearer, easier, and more logical system than the archaic one.

We have described this innovation as advantageous, and we could also call it patriotic as it embodies advancement in our current national intellectual culture; in a way it *places us at the same level as the most civilized nations*.

The obtuse and narrow spirits, fervent enthusiasts of conserving the existing state of affairs, even when proven ill, will qualify the new legislation as hasty and out of place. But it would not be fair to withhold the advancement of a nation just to please such short-sighted people. This will be the march of a nation willing to advance to an honorable place amongst nations. We are sure that the law will be received with joy by the majority of the people in the country.[21]

A similar tone was used by the engineer Tomás Medina Ugarte, from the state of Aguascalientes, in his *Conferencias sobre el sistema métrico decimal de pesas y medidas*, saying that the metric system is

in accord with our numeric base, it facilitates calculation and commercial transactions, due to its decimal progressions and regressions, recognized for its advantage in simplicity and precision for fractions, which rests in a sound indestructible base, which do not belongs to any particular climate, which is accord with recent developments in science, approved by wise men, and *recognized as legitimate and advantageous by the current enlightened nations of the world*.[22]

These examples are representative of the kind of rhetoric used in the diffusion of the decimal metric system during the second half of the nineteenth century. The system

[21] Juan B. Alcocer, *Breves apuntes para facilitar el uso de las tablas que fijan las relaciones entre las antiguas pesas y medidas y las del sistema métrico decimal* (Queretaro: Imprenta de Luciano Frías y Soto, 1896), 3-4. Emphasis added.

[22] Tomás Medina Ugarte, *Conferencias sobre el sistema métrico decimal de pesas y medidas* (Aguascalientes: Tip. de J. T. Pedroza e Hijos, 1896), 4. Emphasis added.

was not only good for its scientific upbringings; it was also recognized by the "civilized" and "enlightened" nations of the world, a group to which Mexican elites wanted so desperately to belong to.

The alleged relationship between the metric system and the benefits of science was articulated by other means other than texts. For example, at the beginning of the Díaz regime it was erected the so called "Hypsographic Monument," laying between National Palace and the metropolitan cathedral.[23] Built by the Ministry of Development, the monument was dedicated to the cosmographer Enrico Martínez to celebrate the completion of Mexico City's great sewage canal. The monument was also known as "The Level," as it indicated the median leveling of some lakes in the valley. It also served to define the capital's coordinates, the depth of the lake of Texcoco, and to mark the center of the country (i.e. it signals the "kilometer zero," the point from which distances of roads are measured). In the words of its creator, civil engineer Francisco M. Jiménez: "This monument will show to coming generations that at this time in Mexico men of science were honored, and, at the same time, that there is a promotion of all that is useful and beautiful."[24] On the four sides of the platform of the monument there were marble standards of the meter (in two of its sides), the yard, the Mexican *vara*.[25] Including the meter and its old counterparts in the monument strengthened the idea that the metric system was a symbol of civilization, science, and progress.

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[23] Nowadays the monument rests in the opposite side to the cathedral.

[24] *El Siglo Diez y Nueve,* May 7, 1878. See also

[25] Adolfo Duclós Salinas, *The Riches of Mexico and its Institutions* (St. Louis: Nixon-Jones Printing Co., 1893), 134-135.

The intimate kinship between the metric system and civilization can also be seen in some aspects of the broader context of scientific activity in Mexico at the time when plans for metrication were taking form. For example, *to measure* and *to civilize* were frequently considered by anthropologists, geographers, and cartographers as twin activities. In this manner, the campaigns to study and measure the bodies of Mexican Indians (phrenology and scientific racism) was seen as part of an effort to transform Indians and incorporate them into a state project centered around the idea of cultural, racial, and economic integration—i.e. to civilize them.[26] Also, by mapping the territory—or measuring the "body" of the nation—it was considered that the nation itself was being created.[27]

Scientists Explain the Masses

Now, if the metric system would bring such a wonderful advantages in the eyes of its promoters, the question comes to mind of how did they explained the huge difficulties in its actual introduction?

Gabriel Ciscar said in 1800, as he pushed for the adoption of the system in Spain, "it could be alleged against the adoption of the new system the repugnance that people

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[26] Beatriz Urías Hoscasitas, "Medir y civilizar," *Ciencias* 60-61 (2001): 28-36.

[27] Laura Cházaro, "Recorriendo el cuerpo y el territorio nacional: Instrumentos, medidas y política a fines del siglo XIX en México," *Memoria y Sociedad* 13 (2009): 101-119; Laura Cházaro, "Del metro universal al mexicano: Controversias en el México del siglo XIX sobre el sistema métrico decimal y la estandarización," in *Metros, leguas y mecates: Historia de los sistemas de medición en México*, ed. H. Vera and V. García Acosta (Mexico: CIESAS, 2011), 137-157.

have towards any innovation."[28] Scientists and politicians in Mexico offered similar justifications when they tried to explain why regular people seemed so reluctant towards using metric measures; it was common for them to mention the ignorance, obscurantism, or plain stupidity of common folk to explain their troubles in trying to make the metric system effective in practice.

But there were more sophisticated arguments as well. In the draft of a law initiative aimed to postpone the official introduction on the metric system it was argued (showing a curious historical sensitivity) some justifications why the system could not be used yet:

> The establishment of the decimal metric system was very hard to implant even in its country of birth [France], despite the fact that patriotism and the energy of the new ideas in those revolutionary times constantly cheered the promoters to carry on with their work of reconstruction and the abolishment of the old systems—which had no more reason to exist—once the new system got created under more solid basis. This effort has had in Mexico its own share of expected difficulties, due *to ignorance and routine, which make repulsive all providences, even if they represent a progress*, and are always in need of new learning by common people. Moreover, the government—focused on preparing the ground and making acceptable the new measures—cannot force a radical change with violent, forceful, and peremptory actions. This change, without the due preparation, could not bring a favorable outcome to the natural and straightforward evolution sought to improve our antiquated systems of weights and measures.[29]

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[28] Gabriel Ciscar, *Memoria elemental sobre los nuevos pesos y medidas decimales* (Madrid: Imprenta Real, 1800), 38.

[29] AGN, Pesas y medidas, box 3, exp. 7. Emphasis added. The document itself has no date or author, but it is included in a file dated December 15, 1890. There is a very good chance that it was written by the engineer Ezequiel Pérez, director of the Office of Weights and Measures.

This line of argument—which considered the large of the population too ignorant to learn the intricacies of the metric system—was, paradoxically, shared by critics of the metric system, like Manuel Payno (whose position on metrication I described in previous chapters). In one his anti-metric articles Payno argued that

> Units of measure of kind and the division of currency […] are a mere convention. Many times nature provides models and standards. Foot, cubit, arm, fingers are standards used by early societies. Uniformity is what matters for a country in this regard—whichever its base is. If that base is chosen wisely, the more perfect the resulting measurement system would be. But asserting that one system implies some progress and a different system implies a kind of backwardness, is assuming a position of the absolute and the infallible that cannot be found in human deeds. Let's assume, for the sake of argument, […] that the French system is an obvious progress. That progress would be so costly to the Mexican people that we should consider the tradeoff between costs and benefits for the next fifty years. Greetings to the engineers, merchants, government employees, and other intelligent people who utilize the decimal metric system; but we cannot force it into those who do not know how to use it and do not have the means to learn it. And that is the majority of the people, completely innocent of this ignorance. They will be condemned to pay dearly during the period that will be needed to change customs and develop proper teaching in the schools.[30]

It is worth notice that the intellectuals' opposition in Mexico against the metric system was visible mainly before the period of implementation started. But the Mexican intelligentsia was galvanized around the pro-metric position by the 1890s.

But let's move now to the case of American intellectuals and their position regarding metrication.

[30] Manuel Payno, "La nueva moneda," in *Periodismo político y social* (Mexico: Consejo Nacional para la Cultura y las Artes, 2001), 371-372.

2. AMERICAN INTELLECTUALS AND THE METRIC SYSTEM: THE CASE OF MELVIL DEWEY[31]

Melvil Dewey (1851-1931) is mostly recognized for his work as an educator and for the design of the decimal classification system for libraries—widely used around the world to catalog and shelve books according to a thematic arrangement. Lesser known, however, is Dewey's five-decade-long effort to introduce the decimal metric system of weights and measures in the United States and his role as founder, in 1876, of the first organization exclusively dedicated to that goal, the American Metric Bureau. Dewey, furthermore, holds the distinction of being the only person to have participated as an active member in all major American pro-metric organizations.

Unfortunately, most of Dewey biographers and scholars interested in the history of the metric system have overlooked Dewey's significance for the American metric movement. His status as the patron saint of modern librarianship has eclipsed his vigorous role in favor of metrication and his participation in several other campaigns aimed to improve education and promote effectiveness in the use of material and human resources—besides advancing plans for library rationalization and wider use of metric measures, Dewey was a passionate adherent of simplified spelling, abbreviations, shorthand, home economics, reform of the Gregorian calendar, and efficiency in all aspects of human life.

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[31] A modified version of this section was first published in *Metric Today* 45 (2010): 1, 4-6.

According to his autobiographical notes, Dewey's interest in metrological reform first emerged at age of fifteen, when he became frustrated by the lack of simplicity in the customary weights and measures and the way they were taught in math classes, particularly in relation to compound numbers. He describes how he became interested in the metric system:

> In school in Adams Center I rebelled against compound numbers. I told the teacher that geometry taught us a straight line was the shortest distance between two points and that it was absurd to have long measure, surveyor's measure, and cloth measure; also absurd to have quarts and bushels of different sizes and to have avoirdupois, troy, and apothecary weights, with a pound of feathers heavier than a pound of gold. I spread out on my attic room table sheets of foolscap and decided that the world needed just one measure for length, one for capacity, and one for weight, and that they should all be in simple decimals like our money. I was puzzling over the names to give the new measures when I read that John A. Kasson of Iowa had passed in Congress a bill legalizing the metric system. I looked it up at once, found that it met my plan ideally and the next week went to our village lyceum and gave a talk on the great merit of international weights and measures. From that day I became a metric apostle.[32]

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[32] Cards titled "Biog metric," in CU, Melvil Dewey Papers, box 67; also reproduced in Grosvenor Dawe, *Melvil Dewey, Seer: Inspirer: Doer, 1851-1931* (Lake Placid Club, N.Y.: Melvil Dewey Biografy, 1932), 277-280. This text was actually written by Dewey using his modified and simplified spelling. Reading in its original form is an interesting exercise into Dewey mind and methods: "In skool in Adams Center I rebeld agenst compound numbers. I told the teacher that jeometri taut us a strait lyn was the shortest distance between 2 points & that it was absurd to hav long mezur, surveyor's mezur & cloth mezur; also absurd to hav quarts & bushels of diferent syzes & to hav avoirdupois, troy & apothecari weits with a pound of feathers hevier than a pound of gold. I spred out on my attik room table sheets of foolscap & desyded that the world needed just 1 mezur for length, 1 for capasiti & 1 for weit & that they should all be in simpl decimals lyk our muni. I was puzling over the names to giv the new mezures when I red that Senator John A Kasson of Iowa had past in Congress a bil legalizing the metrik sistem. I lookt it up at once, found that it met my plan ideali & the next week went to our vilaj lyceum & gave a talk on the great merit of international weits & mezures. From that day I became a metrik apostl."

Dewey's early disposition for simplicity and effectiveness was reinforced after a tragedy that almost took his life. In 1868—when Dewey was seventeen—his school caught fire and he helped to save as many volumes as he could from the burning library, inhaling a great deal of smoke in the process. As a result, Dewey developed a deep cough that caused his doctor to predict that he would not live for more than two years. As a Dewey biographer has noted, the prospect of a premature death made Dewey obsessed with saving time.[33] Efficiency became his creed, and in the years to come this credo shaped his professional interests.

In 1873, while a student at Amherst College, Dewey wrote in one of his reading notebooks, "My heart is open to anything that's either decimal or about libraries."[34] He was at the time intensively studying library economy, research that culminated in the creation of his classificatory system, an invention that permanently linked his name with libraries and the decimal principle.[35]

Dewey's decimal classification for libraries follows a logic similar to that of metric weights and measures (where every unit is divided in ten subunits that can be subsequently divided in ten parts as well, such as the meter, which is fractioned in ten decimeters, one hundred centimeters, one thousand millimeters, and so forth) and the

[33] Wayne Wiegand, *Irrepressible Reformer: A Biography of Melvil Dewey* (Chicago: American Library Association, 1996), 10-11.

[34] Quoted in Wiegand, *Irrepressible Reformer,* 20.

[35] On Dewey's classification project: Markus Krajewski, *Paper Machines: About Cards & Catalogs, 1548-1929* (Cambridge: MIT Press, 2011), 87-106.

American dollar (the decimal currency, invented by Thomas Jefferson, in which an eagle coin had ten dollars, the dollar ten dimes, the dime ten cents, and the cent ten mills).

In devising his system of library classification, Dewey designed a scheme to arrange books in a specific and repeatable order within ten main *classes,* each class with ten *divisions,* and each division with ten *sections*. The whole system was then constituted by ten classes, 100 divisions, and 1000 sections, all of them with an assigned number. Under this format, each field of knowledge, discipline, or topic would have a traceable place, prearranged under an easily readable general framework. For example, in Dewey's first arrangement—that has been periodically updated—the fifth class (number 500) was assigned to the Natural Sciences; the first division in that class was Mathematics (510); and the first section in that division was Arithmetic (511), the second Algebra (512), the third Geometry (513), and so on.

In 1876, Dewey patented the system and published the first edition of his decimal classification and relative index for libraries. Dewey explained there that by applying this system the usefulness of libraries "might be greatly increased without additional expenditure; … with its aid, the catalogues, shelf lists, indexes, and cross-references essential to this increased usefulness, can be made more economically than by any other method."[36] This was vintage Dewey, doing more with less to improve the means of education.

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[36] Melvil Dewey, *A Classification and Subject Index, for Cataloguing and Arranging the Books and Pamphlets of a Library* (Amherst: n. p., 1876), 4. In further editions the book was titled *Decimal Classification and Relative Index for Libraries*.

It was in 1876 also—Dewey being just 25—when he founded three associations, each focused in his main reform plans: the American Library Association (ALA), the Spelling Reform Association (SRA), and the American Metric Bureau (AMB). He functioned as secretary for all three and he alone was in charge of almost all of the associations' tasks. The fact that the three organizations had considerable impact in their respective fields—with the ALA still in operation—speaks of the missionary determination and the sense of opportunity of that young man.

The three programs of reforms sought by Dewey—library efficiency, spelling simplification, and the thorough introduction of metric units in the United States—were part of an overarching vision that was the driving force behind his work: education of the masses. Libraries—Dewey thought—should be well-organized to provide readers, especially those of the lower classes, with readings to shape their taste and intellect. Metrological and spelling modernization would save pupils in elementary and secondary schools considerable time that could then be used to teach other topics.

The American Metric Bureau was the first *explicitly* pro-metric association in the United States. The American Metrological Society (AMS) had started its operation three years before, but it was not openly pro-metric. One the objectives of the AMS was to achieve international standardization of weights and measures, and while the majority of its members were keen on the idea of securing the exclusive use of metric units, it was not part of the stated objectives of the association.

As secretary of the American Metric Bureau, Dewey and was in charge of all basic operations and received no salary for his work. He edited the AMB official publication, the *Metric Bulletin* (later called *Metric Advocate*), first issued in July 1876. F. A. P. Barnard accepted the position of president of the AMB. Barnard was one of the most influential scientists in the country and president of both Columbia College (now Columbia University) and the AMS. Since 1874, he and Dewey had expressed to each other a common interest in metrication and a desire for collaboration.

The mission of the AMB, according to its constitution, was

> to disseminate information concerning the metric system; to urge its early adoption; and to bring about actual introductions wherever practicable. To this end it will secure the delivery of addresses; publish articles, circulate books, pamphlets, and charts; distribute scales and measures; introduce the practical teaching of the system in schools; and in all proper ways, as far as the means at its disposal will allow, the Bureau will urge the matter upon the attention of the American people, till they shall join the rest of the world in the exclusive use of the International Decimal Weights and Measures.[37]

More specifically, the AMB concentrated its efforts on building public awareness of the necessity for metrological reform and attempting to ensure that the metric system would "be taught in the schools, introduced into factories, shops, and homes, used in markets and stores."[38] As part of his interest in education, Dewey negotiated with the powerful Fairbanks Scales and other companies to provide the AMB with low cost metric materials, with the expectation that this would be a good investment for companies once the metric system had been nationally adopted. Dewey distributed these metric supplies

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[37] *Metric Advocate* 38 (1881): 513.

[38] Postcard of the American Metric Bureau, CU, Melvil Dewey Papers, box 66.

to schools and educational institutions interested in teaching and disseminating the new system of measures.

In his dual role as secretary of the American Library Association and the American Metric Bureau, Dewey was able to combine his duties. As chair of the standards committee of the ALA, Dewey was instrumental in setting the standard for library catalog cards in metric units—the Harvard College size of 5 x 12.25 cm and the postal size of 7.5 x 12.25 cm. He promoted the idea that library catalogs should specify the size of books and other printed matter in centimeters instead of using the old book size terms such as folio, quarto, and octavo—today library catalogs in the United States still follow this convention. Dewey was ready to provide libraries with these metric supplies through the Metric Bureau.

In 1876, Dewey commissioned two committees of 20 educators to study the impact of metrication and spelling simplification in school teaching. They reported that using only metric units, abolishing compound numbers, and implementing "scientific spelling" would save the average child three to four years between first grade and graduation from college. Metric reform alone would save a full year of academic education for every student. According to Dewey, "the importance of this is simply incalculable at a time when we find impossible to get our limited courses the subjects it seems necessary to teach. The school life of the average child is now so very short that a system which causes such a waste is a national crime."[39] The results of the study became one of Dewey's favorite weapons in the weights and measures debate.[40]

By the 1880s Dewey's activities in the AMB became less prominent as he focused on his others projects, but he was never fully detached from the metric movement. Besides being the creator of the AMB—and the commanding force behind it—Dewey can be credited as the only person with active membership in the four major pro-metric associations in the United States from the 1870s to the 1930s. From 1887 to 1889, he served as secretary of the American Metrological Society; years later he was a member of the Advisory Board of the All-America Standards Council (a California-based organization that promoted metric unification for all countries in the Americas); and he functioned as member of the Advisory Board and chairman of the Metric Education Committee in the Metric Association (today the U. S. Metric Association).

Dewey's reputation made him a point of reference in the numerous public debates about metrication. In 1904, when legislation related to the introduction of the metric system was being discussed in Congress, James H. Southard, chairman of the Committee on Coinage, Weights, and Measures in the House of Representatives, solicited Dewey to appear before the committee and present his views. Dewey was unable to travel to Washington, but he sent a letter to be read in the hearing. The paragraphs from that missive summarize Dewey's view on the metric system as a civilizatory achievement—

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[39] CU, Melvil Dewey Papers, box 66.

[40] Wiegand, *Irrepressible Reformer,* 43.

comparable to Hindu-Arabic numerals—and his tart opinion about the opponents to metrication:

> [People who oppose the metric system have] protested against railways, steamships, free schools, free libraries, good roads, laborsaving machinery of all kinds, in short against the things which have made modern civilization what it is. […] These people opposed bitterly the introduction of Arabic numerals. They said it was absurd to foist upon English people foreign looking Arabic characters like *3* and *5* […] when our plain roman numerals (III and V) were obvious to every one at a glance as being 3 and 5. They were not less honest, earnest and intelligent than those who have similar difficulties in understanding the decimal system. Your honorable committee have but to pause a few minutes and try to imagine the commercial chaos if the innovators had not pressed the introduction of Arabic numerals and the decimal system which we now beg to establish for weights and measures, following the example of its establishment in arithmetic.
>
> There were similar protests when a few years ago the American Metrological Society, of which I was for some years secretary, secured the adoption of standard time throughout the United States. Learned disquisitions on the trouble, expense and impossibility of such a change were not wanting and yet it was effected with the greatest ease and has been of untold benefit to the country. A still closer illustration is the adoption of the decimal currency in place of the *£*, *s*, and *d*, where 8 shillings made a dollar hare and across of the river in Massachusetts only 6 were required. If the arguments of obstructionists had been listened in these cases, it would have seriously set back the course of civilization and economic development. […]
>
> A really important reason [to favor metrication] is the economic waste. Computation have repeatedly been made and verified to show the countless millions wasted each year by English speaking people because we have so cumbrous a language of weights and measures. […] There are no direct commercial returns to any individual or corporation to justify the labor of converting the public to the new system. Those who realize its advantages wait for others to incur the expense of securing them and inertia carries on the wasteful old method till wise legislators solve the difficulty by requiring the use of cheaper and better forms. It is gain not alone to large interests, but reaches practically to

> every citizen who is sure to have more or less concern in weights and measures in some form.[41]

Dewey followed with attention the public debates on the metric system and was willing to defend the cause. For example, in 1925 he sent a letter to the *New York Herald Tribune* to refute an anti-metric article by Donald Hampson, a member of the American Society of Mechanical Engineers, who argued that metric was only of interest for a "little group of theorists." Dewey rebutted with one his favorite movements when talking about measures reform: first underlining the qualities of the metric system and then placing the adoption of the metric system in line with other intellectual innovations in history, like the calendar or, in this case, the adoption of Hindu-Arabic numerals:

> [Hampson] says "in practice one seldom works with 10s." He writes exactly as did the Englishman who refused to adopt Arabic numerals and protested that I, V, X, L, C and M were so simple and plain that it was absurd to urge an Englishman to learn Arabic. I found in an old book this same argument saying that "everyone knows instantly that V means five, but these iconoclasts would destroy the beautiful simplicity of English measures and tell us that 5 is to be the new character. Away with so foolish an inovation!" And this stupid talk resulted in England being long behind the Continent in adopting Arabic numerals. The mind can hardly grasp what it would mean if we were dependent on Roman numerals today for our computations. It would bring the business world to a standstill, and yet exactly the same arguments were used for them that are now urged against completing the work and having the measures of length, capacity and weight, like measures of numbers, simple decimals.[42]

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[41] Melvil Dewey to James H. Southard, April 13, 1904, Melvil Dewey Papers, box 66.

[42] "Metric Advantages: Melvil Dewey Scores Opponents of Decimal Measures," *New York Herald Tribune,* February 16, 1925.

Till the end of his life, Dewey devoted time and energy to helping organizations focused on promoting social improvement. In 1918 Dewey was named president of the National Efficiency Society, described by him as "a nation-wide movement, not for promoting efficiency in the field where engineers have already done so much, but rather for extending the principles of efficient engineering to all other relations of life."[43] A month before his death, Dewey joined the World Calendar Association, an organization focused on the modernization of the Gregorian calendar, an effort similar to the metric reform but for the calculation of time.[44] Dewey's role in these enterprises was secondary, but represents a natural expansion of what can be called "Dewey's doctrine," the proper and proficient utilization of the resources at hand to create permanent benefices for the majority of people.

Through the decades Dewey's entangled ideas on measurement, efficiency, and language were (knowingly or not) repeated several times by other metric proponents, some of which displayed uncanny similarities with Dewey's rhetoric—that was the case, for example, with science fiction novelist, popular science author, and hardcore metric advocate Isaac Asimov.[45]

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[43] Dewey Melvil, "Efficiency Society," *The Encyclopedia Americana* (New York: The Encyclopedia Americana Corporation, 1918), 9: 719-720.

[44] "Apostle of Simplification," *Journal of Calendar Reform* 2 (1932): 1: 18.

[45] Isaac Asimov, "Forget It!," in *Asimov on Numbers* (New York: Pocket Books, 1978), 131-146; Isaac Asimov, "How Many Inches in a Mile?," in *Today and Tomorrow and….* (London: Abelard-Schuman, 1974), 147-154.

3. HERBERT SPENCER, LORD KELVIN AND THE TRANSATLANTIC BATTLE OF THE STANDARDS

Probably for the contemporary reader it may be difficult to believe that meters and yards were at the center of a long lasting debate that involved some of the most recognizable faces of the scientific and intellectual landscape during the eighteenth and nineteenth centuries. The pertinence of using inches and pounds or centimeters and kilograms, however, was an object of fiery discussions which involved figures like Condorcet,[46] Antoine Lavoisier (the greatest chemist of the eighteenth century), Thomas Jefferson, Pierre-Simon Laplace, James Watt, Dmitri Mendeleev (the greatest chemist of the nineteenth century), John F. W. Herschel, Charles Sanders Peirce, Hebert Spencer, Lord Kelvin, Alexander Graham Bell, Thomas Alba Edison, and a myriad of less famous (but highly relevant in their national and disciplinary contexts) scientists, engineers, entrepreneurs, industrialists, and inventors, around the whole world.

A particularly important chapter in this history was centered on the figures of Spencer and Kelvin in a debate that had a lasting impact in both the United Kingdom and the United States.

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[46] The figure of Condorcet in the history of the metric system is particularly relevant. See for example: Condorcet, "Observations on the Twenty-Ninth Book of *The Spirit of Laws,*" annexed in Antoine Louis Claude Destutt de Tracy, *A Commentary and Review of Montesquieu's Spirit of Laws* (Philadelphia: William Duane, 1811), 261-282; Keith Michael Baker, *Condorcet: From Natural Philosophy to Social Mathematics* (Chicago: University of Chicago Press, 1975), 65; Keith Michael Baker, "Science and Politics at the end of the Old Regime," in *Inventing the French Revolution* (Cambridge, Cambridge University Press, 1990), 156-159; Louis Marquet, "Condorcet et la creation du système métrique decimal," in *Condorcet, mathématicien, économiste, philosophe, homme politique,* ed. Pierre Crépel and Christian Gilain (Paris: Minerve, 1989), 52-62.

In 1896 there were discussions in the British Parliament to pass a bill that would enforce the compulsory use of the metric system.[47] In March and April of that year sociologists Hebert Spencer published four letters—signed as "A Correspondent"—opposing metrication.[48] in London's *The Times.* These letters were then printed as a pamphlet and sent to all members of the House of Commons, some members of the House of Lords, and all representatives in the United States Congress (where a similar bill was being considered). In 1899, when the subject resurfaced in public debates, he came back to the topic publishing another four installments.[49]

In his editorials, Spencer developed two main sets of arguments, some intellectual, others political. The intellectual arguments revolved around the flaws of the metric system and its decimal principle, the virtues of duodecimal systems, and the integration of metrological policies in the context of the historical development of human knowledge. The political arguments articulated a critique of the metric system based on the affinities between metrication and compulsion. Let's see how he articulated these notions (to showcase better their richness and originality I will quote *in extensor* from Spencer's writings).

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[47] On the debates on metrication in Parliament see Bernard Semmel, "Parliament and the Metric System," *Isis* 54 (1963): 125-133 (esp. 130-131); Joseph Mayer, "Parliament and the Metric System. Comments," *Isis* 57 (1966): 117-119.

[48] *The Times*, April 4, 7, 9 and 25, 1896.

[49] *The Times*, March 28, April 4, 8, and 13, 1899. The whole set of eight articles from 1896 and 1899 was later reprinted as "Against the Metric System" and "The Metric System Again," in Spencer's volume of essay's *Various Fragments* (New York: D. Appleton and Company, 1914), 142-170, 225-239. I follow this version for quotations.

Contrary to so many other critics of the metric system, Spencer actually underscored several positive aspects of it ("I yield to none in the love of method and system," he declared). For one thing, he shared with the inventors of the metric system the desire to transform the status quo of measurement ("The chaotic character of our modes of specifying quantities is as manifest to me as to the metricists," he said). Referring to this he added:

> We must go back to the time of the French Revolution, when scientific men were entrusted with the task of forming a rational system of weights, measures, and values for universal use. The idea was a great one, and, allowing for the fundamental defect on which I have been insisting, it was admirably carried out. As this defect does not diminish its great convenience for scientific purposes the system has been gradually adopted by scientific men all over the world: the great advantage being that measurements registered by a scientific man of one nation are without any trouble made intelligible to men of other nations.
>
> […] Of course I do not call in question the great advantages to be derived from the ability to carry the method of decimal calculation into quantities and values, and of course I do not call in question the desirableness of having some rationally-originated unit from which all measures of lengths, weights, forces, &c., shall be derived. That, as promising to end the present chaos, the metric system has merits, goes without saying. But I object to it on the ground that it is inconvenient for various purposes of daily life, and that the conveniences it achieves may be achieved without entailing any inconveniences.[50]

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[50] Spencer, *Various Fragments,* 231, 157, 165, 168.

From this it should be clear that Spencer's was not a defense per se of customary systems of measurement—something that separates him from the majority of the anti-metric intellectuals that came before (and after) him.

According to some notes in his *Autobiography* Spencer had thought about the benefits of a "12-notation" system since the 1840s when he sketched his "Ideas about a Universal Language," that included a "Memoranda Concerning Advantages to be derived from the Use of 12 as a Fundamental Number." It is interesting to notice that he started to develop his preference for a duodecimal system while reflecting on universal languages, one of the favorite topics of many prominent pro-metric proponents—a coincidence that stresses how close Spencer was, in several of his intellectual interests, with nineteenth century metric advocates. A curious note on another affinity is described by David Duncan in *The Life and Letters of Herbert Spencer*: "It is interesting to note how, after experience in the measurement of brickwork at this bridge, the future opponent of the metric system resolved 'to have a foot-rule made divided into decimals instead of into inches.' 'I am trying to bring decimal arithmetic into use as much as possible.' "[51]

Spencer's main purpose was to show that there were "strong grounds for *rational opposition*" to the metric system on the basis that it is "ill-adapted for industrial and trading purposes." For him, one of the principal defects of the metric system was its *decimal* character, which brings "lack of appropriate divisibility." Spencer underlined the fact that people have a need for easy divisions into aliquot parts, like using thirds and

[51] Spencer, *Autobiography,* 613-623; David Duncan, *The Life and Letters of Herbert Spencer* (London: Methuen & Co., 1908), 22.

quarters, but the number ten cannot divide by four or three. He considered this deficiency of the decimal metric system to be "great and incurable."[52]

Spencer was convinced that duodecimal systems (base-12) were greatly superior to the decimal metric one. The great divisibility of 12 made it perfect to solve practical problems:

> The 12-group has an enormous advantage over the 10-group. Ten is divisible only by 5 and 2. Twelve is divisible by 2, 3, 4, and 6. If the fifth in the one case and the sixth in the other be eliminated as of no great use, it remains that the one group has three times the divisibility of the other. Doubtless it is this great divisibility which has made men in such various cases fall into the habit of dividing into twelfths. For beyond the 12 divisions of the zodiac and the originally-associated twelve-month, and beyond the twelfths of the day, and beyond those fourths—sub-multiples of 12—which in sundry cases Nature insists upon, and which in so many cases are adopted in trade, we have 12 ounces to the pound troy, 12 inches to a foot, 12 lines to the inch, 12 sacks to the last; and of multiples of 12 we have 24 grains to the pennyweight, 24 sheets to the quire. Moreover, large sales of small articles are habitually made by the gross (12 times 12) and great gross (12x12x12). Again, we have made our multiplication table go up to 12 times 12, and we habitually talk of dozens. Now, though these particular 12-divisions are undesirable, as being most of them arbitrary and unrelated to one another, yet the facts make it clear that a general system of twelfths is called for by trading needs and industrial needs; and such a system might claim something like universality, since it would fall into harmony with these natural divisions of twelfths and fourths which the metric system necessarily leaves outside as incongruities.[53]

According to Spencer, when people count by twelves instead of by tens, they encounter fewer troubles with fragmentary numbers, and this produces an "economy of

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[52] Spencer, *Various Fragments,* 143, 148, 152-153. As I mentioned in a previous chapter, it was on this ground that Spender questioned the pertinence of using the decimal principle for time reckoning.

[53] Spencer, *Various Fragments,* 155-156.

time and mental effort," a practical advantage of greater importance than "the advantages of theoretical completeness" that characterize the metric system.

Spencer was in favor of a base-12 measurement system. He was well aware that one of the great merits of the metric system was that it put in agreement our decimal numbers system with a decimal system of weights and measures. To do that the creators of the metric system eliminated many duodecimal units and subunits of measurement; in other words they put metrology in tune with the dominant numbers system. Spencer, on the other hand, proposed to do it the other way around:

> We agree in condemning the existing arrangements under which our scheme of numeration and our modes of calculation based on it, proceed in one way, while our various measures of length, area, capacity, weight, value, proceed in other ways. Doubtless, the two methods of procedure should be unified; but how? You assume that, as a matter of course, the measure-system should be made to agree with the numeration-system; but it may be contended that, conversely, the numeration-system should be made to agree with the measure-system—with the dominant measure-system, I mean.
>
> […We need] a small alteration in our method of numbering to make calculation by groups of 12 exactly similar to calculation by groups of 10.[54]

Contrary to so many critics of metrication who argued that a transition to the metric system was too radical and complicated, Spencer actually claimed that the metric system was, in a way, not going far enough. Spencer, like the metric inventors, wanted to synchronize the numbers system with the measurement system. But while the French savants opted for transforming measures, Spencer sought to change the whole numbers

[54] Spencer, *Various Fragments,* 154.

system and make it duodecimal. "It is perfectly possible," he said, "to have all the facilities which a method of notation like that of decimals gives, along with all the facilities which duodecimal division gives. It needs only to introduce two additional digits for 10 and 11 to unite the advantages of both systems."[55]

Only to change our numbers system! This was a reform proposal of the highest magnitude. And by asking for a more radical reform, Spencer stole a page from the pro-metric enthusiast's book. According to him, that a reform would be too difficult to accept by people at a certain point in time does not mean that it cannot be successfully carried out by future generations. And one reform can be more rational and perfect than others (like using a duodecimal rather than a decimal number system), even though it is not popular or it is conceived to be impractical. This bold plan was very optimistic and had at its base a sort of historical-developmental theory of human knowledge. Spencer was confident about the intelligence of future humanity and its ability to fulfill his project. Or as he put it, "Does not experience teach us that the impossibilities of one century become the facilities of the next?"[56]

Spencer was asking for patience and to wait for more favorable conditions—well into the future—to settle the problem of the numbers and weights and measures systems in the most perfect way:

> Do I think this system will be adopted? Certainly not at present—certainly not for generations. In our days the mass of people, educated as well as uneducated, think only of

[55] Spencer, *Various Fragments,* 159.

[56] Spencer, *Various Fragments,* 233.

> immediate results: their imaginations of remote consequences are too shadowy to influence their acts. Little effect will be produced upon them by showing that, if the metric system should be established universally, myriads of transactions every day will for untold thousands of years be impeded by a very imperfect system. But it is, I think, not an unreasonable belief that further intellectual progress may bring the conviction that since a better system would facilitate both the thoughts and actions of men, and in so far diminish the friction of life throughout the future, the task of establishing it should be undertaken.
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> […] Hence I contend that adoption of the metric system, while it would entail a long period of trouble and confusion, would increase the obstacles to the adoption of a perfect system—perhaps even rendering them insuperable—and that, therefore, it will be far better to submit for a time to the evils which our present mixed system entails.[57]

The idea behind Spencer's plan was then that the metric system may have been an improvement in contrast to the current conditions of weights and measures, but it would be a hindrance for future perfection—don't let the good be the enemy of the perfect!, he might have thought. Spencer synthesized his thesis by saying that "rather than establish a fundamentally imperfect system based upon 10 as a radix, it will be better to wait until we can change our system of numeration into one with 12 as a radix; and then on that to base our system of weights, measures, and values: tolerating present inconveniences as well as we may." What he wanted was to leave things "as plastic as possible, so that the greater knowledge and higher capacity of the future should meet with the fewest obstacles to improvement."[58]

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[57] Spencer, *Various Fragments,* 163.

[58] Spencer, *Various Fragments,* 168-169, 234. On this topic, a biographer of Spencer describes this scene "He wrote his well-known articles to *The Times* against the metric system, and brought out a pamphlet soon

Foreseeing the consequences of global metrication and the difficulties of dismantling a future world standard, Spencer saw England and the United States as a barrier to avert disaster:

> if in the United States as well as in England and its colonies, governments prompted by bureaucracies, but not consulting the people and clearly against their wishes, should make universal this gravely defective system, very possibly it will remain thereafter unalterable. When the trade within each nation as well as all international commerce has been unified in method, the obstacles to a radical change may be insuperable; even though most should come to see the great superiority of another method. And should this happen, then men of the future looking back on men of the present will say of them that, having before them a system which they recognized as relatively perfect, they deliberately imposed a relatively imperfect system on all mankind for all time.[59]

Finally, in an interesting move, Spencer implicitly suggested a great human solidarity and agreement—across generations and geographical areas—on the importance of having divisibility in numbers to perform calculations. Then his plan for numerical reform was not only a leap into the future, put also a link with the past:

> I have been struck by the fact that the ancient wise men of the East and the modern working men of the West, have agreed upon the importance of great divisibility in numerical groups. [… the] ordinary mode of dividing the foot-rule results from the experience of centuries; for builders, carpenters, and mechanics, always buying footrules which best serve their needs, have gradually established the most useful set of divisions.

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afterwards on the same subject. His pleasure at its success both at home and in America was like that of a novice over his first victory. He was in such spirits about it that we felt constrained to inquire if he had any system to suggest as a substitute, to which he replied 'No. Leave that to posterity. Why should posterity have nothing to do? It will certainly know what it requires better than we do?' " Two [Arthur George Liddon Rogers], *Home Life with Herbert Spencer* (Bristol: J. W. Arrowsmith, 1910), 195.

[59] Spencer, *Various Fragments*, 170.

> And yet, though the early man of science and the modern men of practice are at one in recognizing the importance of great divisibility, it is proposed to establish a form of measure characterized by relative indivisibility![60]

It was implied in Spencer's argument that metrication represented a rupture with the shared wisdom of humanity—a break for the worst, of course.

The second set of arguments presented by Spencer against the metric system was political—in the same vein as his famous postulates on "man versus the state."

Spencer stressed that the manifest weakness of the metric system was the fact that it could only be introduced by way of compulsion—"its adoption has resulted from the official will and not from the popular will."[61] Furthermore, even using coercive methods the results of metrication campaigns have been mixed:

> To the question "Why have almost all civilized nations on earth" adopted the metric system, I reply that no nation, civilized or uncivilized, has adopted it. It has been adopted by Governments and forced on the people by bureaucracies. No people has ever been asked for its assent. Even the French did not adopt it (so far as they have adopted it) until they were compelled. […]
>
> It is now more than a century since, in the midst of the French revolution, the metric system was established. Adoption of it has been in the main compulsory. As French citizens have been obliged to use francs and centimes, so must they have been obliged to use the State-authorized weights and measures. But the implication of the above statement is that the old customs have survived where survival was possible: the people can still talk in sous and ask for fourths, and they do so. Doubtless "ignorant prejudice" will be assigned as the cause for this. But one might have thought that, after three

[60] Spencer, *Various Fragments*, 160.

[61] Spencer, *Various Fragments*, 165.

> generations, daily use of the new system would have entailed entire disappearance of the old, had it been in all respects better. […]
>
> There lies before me an imposing list of the countries that have followed the lead of France. It is headed "Progress of the Metric System" It might fitly have been headed "Progress of Bureaucratic Coercion." When fifty years after its nominal establishment in France, the metric system was made compulsory it was not because those who had to measure out commodities over the counter wished to use it but because the Government commanded them to do so.[62]

Besides compulsion, Spencer saw other undemocratic aspects in metrication; for example, its planning was always the works of minorities (mainly scientists and exporters), with the inconveniences being shared by all; however the opinion of the majority on this matter is never asked—"name any country where the metric system has been put to the popular vote?" Stressing this point Spencer declared that

> Ten thousand persons intend to make 20 million persons change their habits. The ten thousand are the men of science (by no means all), the chambers of commerce, and the leaders of some trade unions—leaders only, for the question has never been put to the vote of the mass. The 20 millions are the men and women of England with those children who are old enough to be sent shopping. Ten thousand is an over-estimate of the combined bodies who are forcing on the metric system, and 20 millions is an under-estimate of the numbers to be coerced.[63]

Those most negatively affected by compulsory metrication—people of narrow incomes, wholesale dealers, shopkeepers, publicans, hucksters, buyers and sellers of small quantities in towns and villages who would need to replace their measuring and

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[62] Spencer, *Various Fragments,* 234, 148, 165.

[63] Spencer, *Various Fragments,* 237, 227.

weighing appliances, and then relearn new methods of exchange and calculation—were, according to Spencer, people with "experimental knowledge" in matters of "purchases of small quantities for small sums, involving fractional divisions of measures and money." This majority, however, was excluded from the decision-making process of adopting the official measuring system. Forcing the metric system on the population at large, instead of just allowing its voluntary use, was for him a form of "secular popery," a command to all mankind for all time, a universalistic imposition that would change the daily habits of men and women.[64]

Spencer argued that the democratic character of the British society, its colonies, and America would function as an antidote to compulsory metrication. He considered that "among nations less disciplined in freedom than ourselves there is scarcely a thought of resisting *l'administration*" but the will of the "English people"—less submissive than the "continentals"—cannot be so easily overruled by state officials, and should the attempt be made to force the metric system on them, the "resistance will be so determined that the attempt will have to be abandoned."[65]

So these were the central ideas in Spencer's anti-metric articles.

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[64] Spencer, *Various Fragments,* 167-168, 228.

[65] Spencer, *Various Fragments,* 234, 236-237.

Spencer's commitment to stop the introduction of the metric system in his homeland was so strong that he left a clause in his will providing for republishing his anti-metric pamphlet whenever the question of metrication would come to Parliament.[66]

Spencer's Anti-Metric Legacy

The legacy of Spencer's anti-metric stance was large but mixed. On the one hand, the core of his argument—changing the present decimal number system for a duodecimal one—made some waves but faded away rather quietly. Despite the attention that this part of his argument received in some newspapers[67] few people took it seriously. One of the rare exceptions was William Benjamin Smith (a professor of mathematics and amateur historian of early Christianity), who brought this very same idea back in an article in *Science,* during the debates with the World Trade Club in 1919—without acknowledging Spencer, though.[68]

On the other hand, even if Spencer did not defend customary weights and measures as such and he described the existing state of affairs in British metrology as highly imperfect, his arguments against the metric system were used by people interested in actually preserving the old units of measurement and who were not interest in making any kind of metrological reform, less so adopting the duodecimal notation championed

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[66] "Hebert Spencer's Will," *New York Times,* January 14, 1904; "Spencer and the Metric," *San Jose Mercury News*, January, 23, 1904.

[67] See, for example, the article "Doudecimalisms," *Tucson Daily Citizen*, April, 28, 1904; also published in *Baltimore American,* September 18, 1904.

[68] William Benjamin Smith, "Not Ten but Twelve," *Science* 50 (1919): 239-242.

by Spencer. With the conviction that the enemy of my enemy is my friend, anti-metric groups used Spencer's name in their campaigns to stop pro-metric legislation. This meant that they presented vastly fragmented and edited versions of Spencer's writings, cherry picking the excerpts where Spencer questioned metric measures and ignoring his plan for a duodecimal number system.[69] The influence of Spencer—an engineer himself—was visible in the arguments displayed by mechanical engineers in the United States, led by Frederick Halsey and Samuel Dale (as I showed in the previous chapter), who picked up the idea of a "rational opposition" to metrication. This link was explicit as it was common, for example, for Dale's pamphlets to include quotes from Spencer's articles.[70]

A third and unexpected impact of Spencer on the anti-metric movement came from an interpretation of the history of metrology through the eyes of Spencerian evolutionary theory; or more precisely through a broad understanding of what system of measurement ought to perish or prevail based on the *survival of the fittest*—the famous phrase coined by Spencer. Spencer himself did not frame the metric issue in these terms, but several commentators in the weights and measures debates did. See for example this description of Spencer's anti-metric text in the *Baltimore Sun*:

> The pamphlet [...] is a strong presentation of the objections to the metric system and a plea to English-speaking world not to abandon their fundamental standards being, in Spencer's view, a "survival of the fittest," developed through centuries of evolution, and

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[69] For a couple of examples see: A. V. Draper, "Herbert Spencer's Opposition to the Metric System," *Manufacturers Record,* August 26 (1920): 109-112; *The American Machinist* 52 (1920): 1222. On the opposite direction, see "A Word for the Metric System," *Springfield Republican*, January 7, 1906.

[70] See for example the inside covers in Samuel Dale, *The World Trade Club of San Francisco and its Metric Propaganda* (Textiles: Boston, 1920).

he warned against abandoning them for the artificial metric standards which, because arbitrary established, lack the elements of convenience in use.[71]

Something similar can be found when the anti-metric journal *American Machinist* commented on the news of a possible compulsory metric law to be passed in Japan:

> Although […] it will be attempted to make the metric system compulsory in Japan and the law so provides, it is doubtful whether such a result will happen. Almost everything in this world develops from actual necessity. *In the long run the most useful system will survive*. If the leading nations of the world, which are America and Great Britain, to which Japan owes most of her civilization, business methods, etc., decide to retain the English system of weights and measures with some improvement, it is certain that will continue to use the English system out of consideration of actual necessity, without regard to the law, which will be practically ineffective.[72]

Samuel Dale himself used ideas of this sort to defend the opposition to metrication. In a letter to Congressman John W. Gaines (an anti-metric representative from Tennessee), Dale argued that:

> We now have a system that has resulted from a *process of natural selection* since man first began to measure and to weigh. It is a part of our language, gauges our ideas of length, breath and thickness of every object, and is bound intricately and inextricably to all our complicated industries. When I think of the vast ramifications of the subject the idea of altering these standards in the least degree fairly staggers me, and yet a Congressional committee airily propose not only to change but to revolutionize our whole system of measuring and weighing. […] There is no doubt that the metric system can be forced into this country. The trouble will come when we try to use the old and new

[71] "Spencer's Unusual Will," *Baltimore Sun,* July 11, 1920.

[72] "Japan Does Not Favor Adoption of the Metric System in That Country," *American Machinist,* July 14, 1921. Emphasis added.

> standards, and then it will impossible to get rid of the metric virus. The idea that we can drive the old standards out is too absurd for consideration. The only safety is in leaving the people alone to use what system they please without interference from the government. Let the government protect our standards by keeping models of the yard, pound, etc., but let government control end there.[73]

And a few years later, in a newspaper article, Dale came back to this topic and vocabulary:

> Our English system is not the arbitrary scheme of a few men who, meeting behind closed doors in Paris, devised the metric system on the theory that they knew better what the world needed than did the world itself. *Our system is the product of natural law working through the ages to meet the daily needs of unnumbered generations of men*. It is […] an adjunct of a league, which finds its roots in the hearts and minds of the people.[74]

The power of this rhetoric was so prevalent that even people who were pro-metric tried to use it in their favor. Like industrialist Albert Herbert (the maecenas who financed metric organizations like the All American Standards), who in the context of a discussion on the savings in railway costs by switching to the metric system closed up an argument saying that "the survival of the fittest means the survival of the most economical."[75]

The interest aroused by Spencer's article in the United States warranted its republication, a couple of months after it appeared in London, in the June issue of the *Popular Science Monthly*.[76] For this reprint Spencer consented to allow his authorship to

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[73] Samuel Dale to John W. Gaines, January 11, 1904. CU, Dale Papers, box 4. Emphasis added.

[74] Samuel S. Dale, "Yards, Gallons, and Grains: The Economic and Moral Aspects of English Weights and Measures," *The Christian Endeavor World,* November 6, 1919, 106.

[75] Albert Herbert to Melvil Dewey, February 27, 1897. Melvil Dewey Papers, box 66.

[76] Herbert Spencer, "The Metric System," *Popular Science Monthly* 49 (1896): 186-199.

be known.[77] Alongside Spencer's paper appeared a letter by Frederick Bramwell, a British engineer, fellow of the Royal Society of London for the Improvement of Natural Knowledge and former president of the Institution of Civil Engineers, which echoed Spencer's attack on ten-base systems by saying that decimals are "absolutely incompatible with mental arithmetic" and prone to errors in placing the decimal point. In his letter Bramwell attached a long fragment of Napoleon's memoir dictated in St. Helena to Montholon, where the French general attacked the metric system and French savants who invented it (a surprising opinion by the man who was instrumental in the first wave of expansion of the meter by imposing the metric units—alongside with the Napoleonic Code—outside France).

This republication, now with Spencer's name spelled out, generated multiple and loud reactions.

The first response against Spencer in the United States was an article by Thomas Mendenhall that also appeared in *Popular Science Monthly*.[78] Mendenhall, president of the Worcester Polytechnic Institute, was not only a well-known scientist—he served in 1889 as President of the American Association for the Advancement of Science—but allegedly one of the most experienced men in metrology in the country. From 1889 to 1894 Mendenhall was superintendent of the US Coast and Geodetic Survey—at the time

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[77] This was also announced in "Hebert Spencer Opposes Metric System," *The New York Times,* June 22, 1896.

[78] T. C. Mendenhall, "The Metric System," *Popular Science Monthly* 49 (1896): 721-734.

the office in charge of weights and measures in the country[79]—a position considered one the most important scientific appointments in Washington. Under his direction, in 1893, the so called "Mendenhall Order," was imposed. Namely the decision that made the meter and the kilogram the fundamental standards of length and mass in the Unites States, instead of the yard and the pound (this was, more than anything else a technical redefinition, which did not imply changes for people in everyday life). Mendenhall's reply was followed by others from university professors in scientific circles, such as E. E. Slosson's in *Science,* and Oscar Oldberg in *The Bulletin of Pharmacy*.[80]

On the whole, these refutations of Spencer appeared to have a limited effect. In the long run Spencer's arguments changed the dynamics of the discussion on metrication in the United States. He did not frame the problem as a confrontation of nationalistic, religious, and conservative ideas against universal, scientific, and rational principles—as had happened so many times before in these debates. Spencer had no interest in trying to show that imperial measures were God-given units of measurement (as the previous generation of metric opponents did, for example); he did not even pretend to show that customary measures were better than the metric ones.

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[79] This is before the creation of the National Bureau of Standards in 1901.

[80] E. E. Slosson, "Decimal Numeration in the United States," *Science* 4 (1896): 59-62; Oscar Oldberg, "Herbert Spencer vs. the Metric System," *The Bulletin of Pharmacy* 10 (1896): 292-298. Oldberg, a professor of pharmacy at Northwestern University, was a veteran in the promotion, teaching, and defense of metrication; he was the author of *The Metric System in Medicine* (Philadelphia: Presley Blackiston, 1881), and *A Manual of Weights, Measures and Specific Gravity* (Chicago: n.p., 1885). For other articles discussing Spencer see Florence Yaple, "Herbert Spencer and the Metric System," *American Journal of Pharmacy* 76 (1904): 125-128.

Spencer's attack represented a much more pointed challenge to metric advocates than posed by the so-called pyramidologists in the last third of the nineteenth century. Spencer had had an immense influence on American intellectual life since the 1860s. As Richard Hofstadter pointed out, "in the three decades after the Civil War it was impossible to be active in any field of intellectual work without mastering Spencer."[81] Prominent metric advocates, like Frederick Barnard, in occasion of Spencer's visit to New York in 1882, said that the English philosopher was not only "the profoundest thinker" of his time, "but the most capacious and most powerful intellect of all time;"[82] fortunately for Barnard he did not live to see how Spencer—the man who's name, according to his own words, could only be compared in the history of science with Newton's—publicly bashed the metric system, and campaigned to stop metrication in England and America.

Herbert Spencer's articles were important because he provided a thoughtful and technical critique of metrication. A striking contrast with some anti-metric groups which had just been harshly discredited for their persistence in linking English measures with Egypt's Pyramids.[83]

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[81] Richard Hofstadter, *Social Darwinism in American Thought* (Boston: Beacon Press, 1955), 33.

[82] Edward Livingston Youmans (ed.), *Herbert Spencer on the Americans and the Americans on Herbert Spencer* (New York: Appleton, 1883), 87.

[83] On the curious case of the pyramidologists and the opposition against the metric system: John Taylor, *The Battle of the Standards: The Ancient, of Four Thousand Years, against the Modern, of the Last Fifty Years—The Less Perfect of the Two* (London: Longman, Green, Longman, Roberts & Green, 1864); Charles Piazzi Smyth, *Our Inheritance in the Great Pyramid* (London: W. Isbister, 1874); Charles Latimer, *The French Metric System or the Battle of the Standards: A Discussion of the Comparative Merits of the Metric System and the Standards of the Great Pyramid* (Chicago: Thomas Wilson, 1880); Charles Piazzi Smyth, "Long or Short Fractions for Great Natural and National Standards—Earth's Axis of Rotation,"

Lord Kelvin and the Metric System

An interesting twist in the debates around Spencer's anti-metric stance came not from the United States, but directly from England, where a figure equal in size to Spencer's entered the scene. Sir William Thompson (better known as Lord Kelvin) refuted Spencer and used the weight of his name (at the time he was arguably the most famous physicist in the world) to support metrication in the United Kingdom and America—and, as Spencer had before, he delivered his message directly to lawmakers in both countries.

It is extremely rare for the most prominent sociologist and the most celebrated scientist of an era to get entangled in a public debate. But that is what happened in the 1890s with Spencer and Kelvin on both sides of the Atlantic over this metrological polemic.

Kelvin was famous, among other things, for articulating a view of knowledge in which measurement and quantification played a central role. As he famously declared in 1883, "I often say that when you can measure what you are speaking about, and express it

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Nature 30 (1884): 29-30;Charles A. L. Totten, *An Important Question in Metrology Based upon Recent and Original Discoveries: Challenge to "The Metric System," and an Earnest Word With the English-Speaking Peoples on their Ancient Weights and Measures* (New York: John Wiley & Sons, 1884); Frederick A.P. Barnard, *The Imaginary Metrological System of the Great Pyramid of Gizeh* (New York: John Wiley & Sons, 1884); Edward Franklin Cox, "The International Institute: First Organized Opposition to the Metric System," *Ohio Historical Quarterly* 58 (1959): 54-83; H. A. Brück, and M. T. Brück, *The Peripatetic Astronomer: The Life of Charles Piazzi Smyth* (Philadelphia: Adam Hilger, 1988): 95-134; Simon Schaffer, "Metrology, Metrication, and Victorian Values," in *Victorian Science in Context,* ed. Bernard Lightman (Chicago: University of Chicago Press, 1997), 438-474; Eric Michael Reisenauer, " 'The Battle of the Standards': Great Pyramid Metrology and British Identity, 1859-1890," *The Historian* 65(2003): 931-978; Robert P. Crease, *World in the Balance: The Historic Quest for an Absolute System of Measurement* (New York: W.W. Norton, 2011), 151-159.

in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind."[84] His dedication and contributions to measurement were recognized by naming after him the unit of measurement for temperature, the *kelvin*—which became one of the seven base units in the SI (International System of Units, current name of the metric system).

Kelvin was a harsh critic of English customary measures and according to witnesses that was one of his favorite topics during lectures. Referring to what he called "the British no-system" of measurement he said:

> It is a remarkable phenomenon, belonging rather to moral and social than to physical science, that a people tending naturally to be regulated by common sense should voluntarily condemn themselves, as the British have so long done, to unnecessary hard labour in every action of common business or scientific work related to measurement, from which all the other nations of Europe have emancipated themselves.[85]

Shortly after Spencer published his final anti-metric collaborations in 1896, Kelvin wrote a letter of his own to *The Times* defending the idea of England going metric. There Kelvin contrasted the "uniform simplicity" of the metric system with the "monstrous complexity of British measurements."[86] It is not clear whether Kelvin knew if

[84] William Thompson, "Electrical Units of Measurement," *Popular Lectures and Addresses* (London: Macmillan, 1891), 80.

[85] Quoted in Silvanus P. Thompson, *The Life of Lord Kelvin* (New York: Chelsea Publishing Company, 1976), 436.

[86] "The Metric System," *The Times*, April 30, 1896; Kelvin sent also a brief addition to the newspaper, *The Times*, May 1, 1896. The first of these contributions was republished in the United States a month later: "Lord Kelvin on the Metric System," *Science* (May 22, 1896): 765-766.

Spencer was the author of the four anonymous letters. Whatever the case, this was not the first time that these two colossal figures confronted each other publicly on this very topic.

In 1895 Spencer wrote a lengthy letter to Kelvin, who had made pronouncements favoring metrication.[87] In February of that year Kelvin replied to Spencer:

> Dear Mr. Spencer—It is the uniform simplicity of the French metric system which gives it its great advantage. This advantage it would still have even if the Arabs had counted by aid of their ten fingers and thumbs and two ideal digits, and had given us a duodecimal system of arithmetic. I quite agree with you as to the convenience of halves and quarters in coinage and in weights and measures. It is universally found convenient to take halves and quarters of the smallest unit in any particular measurement in practical use. Lengths on a road, being measured in kilometres, all people would frequently use 1/2 and 1/4 kilometres for convenience: never 1/8 or 1/16. The 1/8 and 1/16 are so many curses to British mechanics, disabling them in comparison with mechanics *of* all other countries except England and America. Mechanics of other countries use 1/2 and 1/4 centimetres when they find it convenient to do so. Miles, furlongs, perches, roods, yards, feet, inches, acres, square yards, square feet, square inches, cubic yards, cubic feet, cubic inches, cause enormous loss of efficiency to English engineers, and really involve a great national loss in useless labour, month after month, and year after year. We may extend the anathema to cwts., lbs. (avoirdupois), lbs. (troy), ounce (troy), dwt,, scruples, grains, gunmakers' drams, apothecaries' drams, gallons, pints, quarts, gills.
>
> You say 'I see you have been tacitly urging,'—I have never tacitly when I have had an opportunity of speaking out.
>
> I wish you could be convinced, and give your powerful influence to a reform which is much needed, and from the want of which we in England, all of us, suffer every day of our lives.—Yours very truly, Kelvin.

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[87] Duncan, *The Life and Letters of Herbert Spencer*, 379.

P.S.—Excuse haste, as I am writing, walking about in my laboratory among sufferers from our mischievous British system, or rather want of system, in weights and measures.[88]

A few years later, on April 24, 1902, Kelvin appeared before the House Committee on Coinage, Weights, and Measures in the United States to endorse the adoption of the metric system in America—the *New York Times* described the event as "the remarkable spectacle of a member of the British nobility appearing before Congressional committee and urging the passage of a house bill."[89] There Kelvin voiced his frustration with England's lack of action, but expressed his belief that if the United States would take the lead in adopting the metric system, his own country would follow suit.[90] Kelvin also used the opportunity of the hearing to go right after Spencer:

> Mr. Herbert Spencer argued that if we were to make a change at all it ought to be to the duodecimal system of arithmetic, and corresponding denominations in measurement. We had better wait until we have 6 digits on each hand before we refuse to be satisfied with the experience of mankind in the experience to old Arabic numeration. But even if we had a duodecimal arithmetic it does not affect the metrical question. We would have the French system just the same, founded on one definite set of units, the meter for length, the square meter for area, the cubic meter for bulk, and for the ton a cubic meter of water.[91]

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[88] Quoted in Thompson, *The Life of Lord Kelvin*, 1121-1122.

[89] "Lord Kelvin a Witness," *New York Times.* April 25, 1902; see also Harold Issadore Sharlin, *Lord Kelvin, the Dynamic Victorian* (University Park: Pennsylvania State University Press, 1979), 234. In that occasion George Westinghouse, the American inventor and entrepreneur, also testified as well in that session in favor of metrication.

[90] For some negative reactions to Kelvin and metrication, see *Springfield Republican*, April 26, 1902.

[91] *Supplemental Hearing on the Subject of the Metric System of Weights and Measures: Hearings before the United States House Committee on Coinage, Weights, and Measures, Fifty-Seventh Congress, First Session, on Apr. 24, 1902* (Washington: Government Printing Office, 1902), 8.

A couple of years after this visit to the United States Congress Kelvin participated in the debates in the House of Lords, pushing again in favor of strong metric legislation: "experience has proved that the change from the system that has been in use in this country to a new system cannot be made over the whole country voluntarily. It is a case for compulsion, and I think the Legislation will be thanked by the country for having applied compulsion."[92]

With this call for a mandatory metric policy Kelvin hit the nail on the head. The essential problem with countries like the United States was (as I stressed in chapter two) the lack of compulsory regulations, as all voluntary transitions to the metric system that have been intended have ultimately failed (a fact well known by Spencer and many other antagonists of the metric system who made the opposition to any compulsory legislation the centerpiece of their public opinion campaigns).

4. THE METRIC SYSTEM AND ITS MODERN COMPETITORS

In the initial chapter I mentioned that one of the great stories in the history of the metric system was the marginalization and obliteration of hundreds of measuring systems—and the corresponding thousands of units of measurement—around the world when the meter, liter, and kilogram were adopted country after country during the nineteenth and twentieth centuries. A lesser-known aspect of the process of global

[92] Quoted in Paul Tunbridge, *Lord Kelvin, His Influence on Electrical Measurements and Units* (London: Institution of Electrical Engineers, 1992), 13 (see also in this book 8-16, 69-70, 88-91). For some examples of the echo of Kelvin in the metric debate in the America almost two decades later: *San Jose Mercury News*, August 20, 1919.

diffusion of the metric system is the confrontation of the metric system against a number measurement system created *ex professo* by scientists and engineers to challenge it. The overwhelming triumph of the metric system in scientific circles over these challengers helped greatly to its ultimate global success, as experts in different countries were able to present—most of the times—plans for metrological reform centered lonely around the metric system (and they avoided then intestine disputes to define what system should be used to supplant customary measures). Since the second half of nineteenth century lack of national metrological uniformity and absence of international coordination in weights and measures were illnesses that found everywhere one and only one prescription: metrication.

The inadequate understanding of this phenomenon and the scarcity of investigations on who and when tried to challenge the metric system with newly measurement systems may create the impression that that those plans were not a factor in the history of metrication.[93] Thus, commentators like Andro Linklater have argued things like this: "left without competition as the only scientifically based, decimalized measurement, the French meter has taken its present place as the simplest, most accurate means of measuring everything between the dimensions of a quark and a black hole."[94]

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[93] One of the few accounts of competitors to the metric system that I know is George Adam, "Alternatives to the Metric System, Based on British Unit," *Decimal Educator* (1935), 17: 43-46, 18: 11-12, 20-21, 28-29. See also Ronald Zupko, *Revolution in Measurement: Western European Weights and Measures since the Age of Science* (Philadelphia: American Philosophical Society, 1990), 209-225.

[94] Andro Linklater, *Measuring America* (New York: Walker and Company, 2002), 260.

This is a misconception. In reality there was plenty of competition to the metric system. For once, at the end on the eighteenth century there were many plans for metrological reform that came about shortly before or simultaneously to what the French savants were doing in the early 1790s. Just to mention a few of them, there were plans formulated by Cesare Beccar in Italy, by James Watt in England, and a couple more—by William Waring and Thomas Jefferson—in the United States.[95]

And once the metric system was established and started its global dissemination many other proposal were advanced to challenge it. With very preliminary information I have been able to collect a sizable list of publications from England and the United States, printed between 1851 and 1889, aimed to displace the metric system (there were, of course, attempts to do the same in other countries[96]):

- Henry Taylor. *The Decimal System, as Applied to the Coinage & Weights & Measures of Great Britain*. Groombridge and Sons, 1851.
- J. S. H. Aslit. *Decimal Coinage: With a Proposal for Decimalizing our Weights, and Measures of Length and Capacity*. London: Silverlock, 1854.
- William Henry Jessop. *A Complete Decimal System* of *Money and Measures*. Cambridge, 1855.

[95] See Marcello Maestro, "Going Metric: How It All Started," *Journal of the History of Ideas* 3 (1980): 479-486; *The Papers of Thomas Jefferson* (Princeton: Princeton University Press, 1971), 16: 619-623; "James Watt: Pioneer of Decimal Systems," *Decimal Educator* (1936): 19: 9-10.

[96] In Spain, for example, Vicente Pujals de la Bastida. *Sistema métrico perfecto ó docial: y demostración de sus inmensas ventajas sobre el decimal y sobre todo otro sistema de medidas, pesos y monedas* (Madrid: Imprenta de la Esperanza, 1862).

- C. E. Macqueen. *The Advantages of a Complete Decimal System of Money, Weights and Measures*. Liverpool: Financial Reform Association, 1855.
- John Felton. *The Decimal System: An Argument for American Consistency*. New York: G.P. Putnam & Co., 1857.
- *Report of the Joint Special Committees of the Chamber of Commerce and American Geographical and Statistical Society on the Extension of the Decimal System to Weights and Measures of the United States*, 1857.
- John William Nystrom. *Project of a New System of Arithmetic, Weight, Measure and Coins: Proponed to Be Called the Tonal System, with Sixteen to the Base.* Philadelphia: J. B. Lippincott & Co., 1862.
- W. Wilberforce Mann. *A New System of Measures, Weights & Money; Entitled the Linn-Base Decimal System and Designed for the Adoption of all Civilized Nation as the One Common System.* New York: University Publishing Company, 1871.
- W. Wilberforce Mann. *A Decimal Metric New System Founded on the Earth's Polar Diameter, and Designed for the Adoption of all Civilized Nation as the One Common System.* New York: University Publishing Company, 1872.
- Alfred B. Taylor. "Octonary Numeration, and its Application to a System of Weights and Measures." *Proceedings of the American Philosophical Society* 24 (1887), 296-366.
- Edward Noel. *Science of Metrology or Natural Weights and Measures: A Challenge to the Metric System*. London: Edward Stanford, 1889.

A person who gave some consideration to one of these publications was todays celebrated philosopher Charles S. Peirce, who at the time worked as metrologist at the US

Coast and Geodetic Survey.[97] In 1890 Peirce reviewed *The Science of Metrology,* by E. Noel. There Peirce showed great skepticism towards the proposed plan:

> Mr. Noel's system is nearly as complicated and hard to learn as our present one, with which it would be fearfully confused, owning to its retaining the old names of measures while altering their ratios. […] The scheme is not without merit, and might have been useful to Edward I. Even at this day it must at least have afforded some agreeable occupation to its ingenious and noble author, not to speak of the arithmetical practice.[98]

And making a diagnostic of the metrological present situation and future in the country, the he added:

> The whole country having been measured and parcelled in quarter sections, acres, and house-lots, it would be most inconvenient to change the numerical measures of the pieces. Then we have to consider the immense treasures of machinery with which the country is filled, every piece of which is liable to break or wear out, and must be replaced by another of the same gauge almost to a thousandth of an inch. Every measure in all this apparatus, every diameter of a roll or wheel, every bearing, every screw-thread, is some multiple or aliquot part of an English inch, and this must hold that inch with us, at least until the Socialists, in the course of another century or two, hall, perhaps, have given us a strong-handed government. We can thus make a reasonable prognosis of our metrological destinies. The metric system must make considerable advances, but it cannot entirely supplant the old units. These things being so, to "challenge" the metric system is like challenging the rising tide. Nothing more futile can well be proposed, unless it be a change in the length of the inch. Nevertheless, there is a goodly company of writers to

[97] See Victor F. Lenzen, "The Contributions of Charles S. Peirce to Metrology," *Proceedings of the American Philosophical Society* 109 (1965): 29-46. Also: Charles S. Peirce, "Testimony on the Organization of the Coast Survey," in *Writings of Charles S. Peirce* (Bloomington: Indiana University Press, 1982), 3: 149-161.

[98] Charles S. Peirce, "Review of Noel's *The Science of Metrology*," in *Writings of Charles S. Peirce, 1886-1890* (Bloomington: Indiana University Press, 1982), 6: 378-379.

> keep the Hon. Capt. Noel in countenance in conjoining these two sapient projects. None of these gentlemen supports the constructive parts of the other's propositions; but they are unanimous against the metric system and the existing inch.[99]

This was a very accurate and neat explanation and prediction of why the metric system would not fully replace the customary system, but also why challenging the metric system was not a great idea either.

The metric system succeeded in replacing hundreds of customary methods and units of measurement around the world that had existed for centuries. Provably equally surprising is the fact that no other modern and scientific measurement system designed in the nineteenth century was able to challenge it seriously. The metric system achieved then a double victory.

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[99] Peirce, "Review of Noel's *The Science of Metrology*," 6: 378.

CHAPTER V

Popular Reception, Appropriation, and Opposition to the Metric System

Such thirst
to know how much!
Such hunger
to know
how many stars in the sky!
…
Friend, we had the time
so our thirst could be satisfied,
the ancestral longing
to enumerate things
and total them,
reducing them
until rendering them dust,
dunes of numbers.
We are papering
the world
with figures and ciphers,
but
the things existed
nonetheless, fleeing
all tallies,
becoming dehydrated
by such quantities, leaving
their fragrance and memories,
and the empty numbers remained.[1]

Pablo Neruda

Measure is intimately connected with man and the things he values above all others: land, food, and drink. It metes out to him what his destiny has failed to afford him in abundance. Sometimes fate will give him a full measure, but often, it will be a short one. Measure is not a convention but a value. It is never neutral: it is good or bad; or rather, there are countless bad measures, and only one, the one "of old," that is just, and "true," and "good." [2]

Witold Kula

[1] Pablo Neruda, *Ode to the Numbers.* Translation by William Pitt Root.

[2] Witold Kula, *Men and Measures* (Princeton: Princeton University Press, 1986), 17.

The process of implementing the decimal metric system reveals many aspects of how scientific ideas circulate across national boundaries and social classes. The history of the metric system, in this regard, intertwines processes of scientific and commercial globalization with the birth of modern national states. It is a history of the relationship between capitalism, statecraft, and science, for even though the metric system was born as a plan made by scientists, it was launched and spread among billions of lay people through commerce and public policies. The case of the metric system illustrates how scientific ideas are distributed not only among members of the enlightened elite, but also through wider groups.

This chapter is focused on how this scientific language (the metric system) was appropriated, reinvented, and manipulated by the Mexican population at large: peasants, peddlers, clerks, lawyers, municipal employees, bakers, bricklayers, bazaar buyers, carpenters and so on. Here I want to show how the "man on the street" (persons who operate according to a vague "knowledge of recipes," following procedures that can be trusted even if they are not clearly understood)[3] coped with the imposition of an exotic, technical lingo that began to appear in shops and government offices.

I will analyze who accepted the new measures voluntarily, who had to be coerced into it, and what forms of opposition appeared. In Mexico the reception of the metric system was slow and difficult; for the most part people did not oppose metrication openly, but a very effective "passive resistance" became pervasive. The public at large,

[3] Alfred Schutz, "The Well-Informed Citizen: An Essay on the Social Distribution of Knowledge," in *Collected Papers II* (The Hague: Martin Nijhoff, 1976), 122.

small merchants, and some local authorities simply ignored the regulations that banned customary measures and kept on using them (especially in rural areas).[4] But I will pay attention also to a peasant revolt against the introduction of the metric system in the Mexican southern state of Oaxaca, where more than one thousand Indians stormed the town of Juquila and killed the local authorities. I will then compare this rebellion with a similar event in Brazil, known as the "*Quebra-Quilo* revolt." The actions of the rebels are framed, analytically, as part of a larger tradition of uprisings against changes in systems of measurement, and these actions are interpreted as being guided by a "moral economy of measurement."

But first, I will describe some of the *strategies of appropriation* that people developed to cope with the metric system, and explain some of the structural conditions that account for the death of customary measures.

1. HOW PEOPLE APPROPRIATED THE METRIC SYSTEM

> Telling a farmer only that he is leasing twenty acres of land is about as helpful as telling a scholar that he has bought six kilograms of books.[5]
>
> *James C. Scott*

It is hard to step into the shoes of nineteenth-century people who faced the banning of the employment of the customary measures that they had used for generations. Perhaps the closest examples we have in recent times to compare with that monumental

[4] For a firsthand account on the introduction of the metric system in a rural setting: Jesús Guzmán Urióstegui, *Evila Franco Nájera, a pesar del olvido* (Mexico: INEHRM, 1995), 31.

[5] James C. Scott, *Seeing Like a State* (New Haven: Yale University Press, 1998), 26.

overhaul in Mexico—even if not equivalent in magnitude—are the 1993 monetary reform that introduced the so called "new peso" (that stripped three zeros from the peso, forming a parity of one new peso for one thousand "old pesos"), and the introduction of daylight savings in 1996.

Those transitions were successfully planned and executed by the government, even if they were not easy to assimilate by the population. For many years people continued to carry out commercial transactions thinking in terms of the old currency and translating economic calculations to their familiar "old pesos," estimating a price of three thousands pesos, for example, saying things like "this costs around three million old pesos." And up until recently, when the time came to adjust to daylight saving time, there were complaints in media outlets and among government officials questioning its usefulness; people resented having an hour "stolen" from their meager rest time without seeing any palpable benefit. But these two campaigns were quickly implemented and ultimately successful.

In turn, the metric reform was much more complicated than putting clocks and watches back or forward one hour twice a year, or subtracting three zeroes from prices. The change in weights and measures was carried out in a less favorable context in order to coordinate collective actions and disseminate information—at the time the main communication media were newspapers and only a thin layer of the population was literate.

One of the first obstacles people had to deal with was the names and prefixes of the new measures, some of which had great similarities in their spelling and pronunciation among them, like decameter (ten meters) and decimeter (one tenth of a meter). Authorities tried to simplify the form in which measures were named in order to lessen the confusion. As Ezequiel Pérez, director of the Weights and Measures Department stated:

> It has been determined that when the national system of weights and measures comes into effect that the pronunciation of metric units in Greek should be reduced to the minimum; as it is more clear to say "10 kilograms," than "one deca kilogram." For convenience the use of Greek should be restricted to units like liter, meter, and gram; but this has not been possible as the hurtful custom has arisen of naming in Greek all the units and measures as well as their multiple and submultiples. […] There is another deeply rooted unlawful practice, that of using *doubles* and *halves*; so people talk about half decaliter, double decaliter, double liter, etc., even though it is easier to say five liters, twenty liters, two liters, and so forth.[6]

An even greater complication was the valuation of certain commodities. This problem is similar to the perplexity that non-British people feel when they weigh themselves on bathroom scales to discover that the result is not displayed in kilograms or pounds, but in stones, which turns 62 kilograms (or 136 pounds) into 9.7 stones. To assert at a glance how many kilograms are in a stone is not an easy task, and for many, a calculator would be required. For people who did not grow up in Great Britain, getting used to making calculations in stones requires a considerable amount of time. Something similar to this is what the Mexican population faced when the metric reform was passed and they were forced to think in terms of meters and grams.

[6] AGN, Pesas y medidas, box 4, exp. 9.

A practical solution devised by the people—and facilitated by merchants—was to make *translations* between the old and the new system. For example, a weights and measures inspector in the state of Veracruz found that in some commercial establishments certain products were frequently sold the by the exact but rather odd weights of 46 kg, 23 kg, and 11.5 kg. As it turned out, these were the equivalents of old measurement units, the *quintal*, the half *quintal,* and the *arroba*.[7] This kind of practices show how sometimes people did not use the new system as it was intended; they rather used it only as a façade to "disguise" the old measures.

An identical phenomenon occurred with the use of decimal currency. Bakers used to sell bread for 1.5, 3, 6, and 12 cents—i.e. equivalents of the old coins *tlaco*, *cuartilla,* half *real* and *real*. To address these problems the authorities ordered that the new decimal measures and coins should be the base of all transactions in order to abolish the custom of using the old system; thus, for example, bread should cost 1, 2, 5, 10, and 15 cents.

Another strategy developed by people to appropriate the metric units was the opposite of what I just described. Instead of disguising old measures as metric ones, the new decimal values were assigned to customary units; for example, in rural areas in the state of Zacatecas a *fanega* became a one-hundred-liter measure, *cuarterones* were turned into an exact measure of two liters, and *cuartillos* became half a liter. This made it easier for people to perform mental arithmetic. It is important to note though, that these equivalents were not uniform across the country. In some regions where traditional units

[7] AGN, Pesas y medidas, box 4, exp. 13; see also, "La ley de pesas y medidas es obra muerta en Yucatán," *Revista de Mérida* July 8, 1897.

were adjusted and rounded to metric measures, the *cuartillo* was 1.5 liters and in other states it was two liters (i.e. three times more than in Zacatecas).[8]

A third strategy to cope with the new system was the creation of *hybrids*, like combining the name of the old unit with a *metric* "surname," designating a new value to it. This was the case, for example, with the *quintal*, which traditionally meant "one hundred pounds," which became the *quintal métrico*, equal to "one hundred kilograms." The same happened with the *tonelada* (traditionally equal to 20 *quintales*) which was replaced later with the *tonelada métrica* (metric ton) with the value of "one thousand kilograms."

Another translation scheme was *monetary*. The fact that many non-decimal coins still circulated in the country during the second half of the nineteenth century made it hard for people to use the new metric measures, as it is easier to make calculations about the relationship between price and quantity when the measurement and monetary systems share the same numerical base—whether it be decimal or duodecimal. If ten meters of cloth was worth seven pesos it was relatively easy to work out that every meter cost seventy cents; the decimal progression in both measures and money made that calculation straightforward. But things were not so easy in the actual world. At that time, the peso could be divided into eight *reales* and one *real* into twelve *granos*. Using this currency it was rather complicated to determine how many *reales* or *granos* a meter of cloth could cost. To take full advantage of the theoretical benefits of the metric systems it was

[8] Dirección General de Estadística, *Medidas regionales* (Mexico: Secretaria de la Economía Nacional, 1937), 199, 615.

necessary to employ it concurrently with a decimal currency.[9]

It was in this troubled and poorly planned terrain, and with an erratic guide from the government, that Mexicans started to make the decimal metric system their own. Little by little the new measures permeated daily life. The country went through a period of *metrological bilingualism*—something very common in countries adopting the metric system—where customary and metric measures coexisted for a long time. Signs of this can be found, for example, in late nineteenth century cooking recipes, aimed at housewives, in which the instructions on the quantities of ingredients were specified in grams and liters, and in pounds ounces.[10]

A similar process could be seen as well in the transmutation of some idioms and popular sayings, like, "seis pies de tierra" (six feet under) which became "tres metros bajo de tierra" (three meters underground). Other popular sayings started to mix old and new units: "Por mucho que haga la vara, no podrá llegar a metro" (No matter what the *vara* does it will be never be a meter); "Litro por litros te venden la leche, el azabache por onzas" (Milk is sold in liters, *azabache* in onunces); "Un gramo de previsión vale más que una tonelada de curación" (A gram of foresight is better than a ton of remedies).[11]

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[9] On this issue see Constancio Gallardo, "El sistema métrico decimal," *Boletín de la Sociedad Mexicana de Geografía y Estadística* 10 (1863), 550.

[10] See for example *Almanaque Bouret para el año 1897* [facsimile] (Mexico: Instituto de Investigaciones Dr. José María Luis Mora, 1992), 182-184. On this topic see Kenya Bello and Claudia Rivera, "¿Qué tanto es tantito? Historia de las medidas en la cocina mexicana," in *Metros, leguas y mecates: Historia de los sistemas de medición en México,* ed. H. Vera and V. García Acosta (Mexico: CIESAS, 2011), 159-179.

[11] For the compilation of sayings see Academia Mexicana de la Lengua, *Refranero mexicano*, http://www.academia.org.mx/dicrefran/DICAZ/inicio.htm, accessed August 8, 2008.

There are multiple reports and indications to suggest that in the 1890s for the majority of people metric measures were little more than a “theoretical oddity” or a merely scholastic curiosity. An example of this can be found in an ironic popular song called *Mariana* that appeared in the final years of the nineteenth century:

> There is no question that I am
> the most scientific man in the world,
> I know chemistry, rhetoric, botanic,
> and the metric system.[12]

But despite this it was clear that little by little people started to incorporate metric units into their vocabulary, routines, and imagery. For instance, there were some greetings cards that showed messages that illustrate a fair degree of familiarity with the newly acquired metrological language, like this[13]:

> Prescription:
> Buy in the “Prosperity” drugstore this formula:
> 100 grams of money, 100 grams of health,
> 100 grams of good fortune, 65 grams of harmony.
> Prescribed to Mr _________
> by your friend __________.

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[12] The song dates from ca. 1898 according to Vicente T. Mendoza, *La canción mexicana. Ensayo de clasificación y antología* (Mexico: UNAM, 1961), 498-99. I own this reference to Said Infante.

[13] Quoted in González Navarro, *El Porfiriato*, 406.

At their own pace and advancing along crooked paths, Mexicans made their way to making the metric system their own.

Policing Popular Appropriation

Today we may consider the popular tactics of appropriation displayed by people to adopt the metric system as creative and ingenious, but seen through the eyes of the state agents it was rather anarchy and chaos.

Government officials in Mexico were not only concerned with the units of measurement that people had to use, but also with how they used numbers. For the metric system to be fully effective it is necessary to use the decimal point instead of fractions (we have to remember that it is the predominance of the ten digits of the Hindu-Arabic numerals what makes decimal systems more suitable for large and complex calculations). The National Bureau of Weights and Measures imposed a police that forbade merchants, accountants, and bureaucrats from using non-decimal fractions or to tally quantities by the dozen. So in bookkeeping records they could not write “3/4 of kilo;” instead they were required to write “0.750 kg” or “750 grams.” Similarly, a package of shirts could not announce its contents saying, for example, “6 dozen shirts,” but rather “72 shirts.”

Contrary to the idea that the transition from customary to metric measures was complicated only to people with little or no formal education in arithmetic, the problems of learning and employing the system was felt also among persons used to performing complex arithmetical operations in their daily life. In 1900 the Secretary of Finance petitioned the Department of Weights and Measures for permission to allow their custom clerks to record quantities in their books with fractions instead of using the decimal point (as the 1895 law required). In their petition they argued that "it is the same to say 1/2 kilogram as 500 grams; 1/4 meter as 25 centimeters." However, Ezequiel Pérez, the federal director of Weights and Measures—a restless and meticulous bureaucrat—was not convinced and reminded the Secretary of Finance that all public servants were expected to express lengths, surfaces, volumes, and weights using metric units ("which are decimal even in written form," as he stressed) in all official documents.[14] This sort of civil war on the use of numbers shows that using the decimal point—one of the cornerstones to justifying the superiority of the metric system—was not easy to master even by trained personnel. And this was not an isolated episode; there are records that show that this and similar problems existed among people working in custom houses since the 1840s.[15]

All these are echoes of a very old problem that has plagued the diffusion of the metric system everywhere since the end of the French revolution. Witold Kula, for example, mentions a critique by the Commission of Weights and Measures of the Cisalpine Republic, in 1801, saying that "Every girl and every unlettered tailor knows what half a quarter-ell stands for; but we would lay a hundred to one that many

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[14] AGN, Pesas y Medidas, box 23, exp. 13.

[15] See, for instance, *Instrucción para reducir fácilmente las pesas y medidas extranjeras designadas en el artículo 15 del Arancel de Aduanas Marítimas, decretado en 4 de octubre de 1845, a las pesas y medidas mexicanas* (Mexico: Imprenta de Torres, 1846), 4.

professional accountants would be unable to assure you that half a quarter-ell is equal to one hundred and twenty-five thousands."[16]

Sometimes, to avoid the annoyance of observing the intricate orders set by the government to weigh and gauge, a secret alliance was forged between shopkeepers and their customers in order to ignore the metric legislation. Merchants found ways to cheat local authorities in an ongoing make-believe charade to simulate that they employed metric units. Some of them, for instance, advertised their products without defining any unit of measure, and other fixed product prices in reference to the old monetary system (the one the public actually understood).[17] Weights and measures inspectors found that there were commercial establishments that used meter sticks with a discreet scratch marking exactly the length of an old *vara,* so customers would feel comfortable buying by *varas,* which was standard that they knew by heart. There must have existed multiple other subtle ways to keep using customary measures behind the appearance of abidance to the metric law. Both vendors and customers felt more comfortable using pounds and *varas* than kilos and meters, and secretly worked in conjunction to evade the authorities' vigilance.

This was not a Mexican peculiarity, as this practice can be found in many other countries. See for example this description regarding Puerto Rico: "The merchants, generally, acquired a complete set of metric weights and measures, and after having them officially tested, kept them only for presentation to the public officers when they were

[16] Kula, *Men and Measures*, 83, 250.

[17] AGN, Pesas y medidas, box 114, exp. 1.

required to do so, which seldom happened, and used in their daily transactions the old, illegal and, frequently, fraudulent instruments."[18] Yet again, we should take care not to consider this as a simple merchant's maleficence. With all probability the employment of all measurement apparatus to conduct small scale commerce was a pact between buyers and sellers to evade metric vigilance and keep transactions running with the units that were familiar and understandable to all.

But government officials are not the only ones interested in disciplining the metrological creativity of people.

Due to medical conventions, some of our first experiences in the world outside of the womb are to be weighed in a scale, have our feet, hands, and body length measured, and to be penetrated by a rectal thermometer. In other words, one of our first experiences outside the womb is to be measured. Symmetrically, hours after death our measures will be taken again in order to prepare a coffin of the appropriate size. These are a fitting beginning and end for our lives, as we are permanently measured and self-measured.

Medicine and pharmacy are fields where experts and laypeople need to interact through a language of quantity—a language that, of course, has to be mutually intelligible. Prescriptions are not just coded messages between physicians and pharmacists, they are also instructions to the patients and their families—instructions mainly about medicine doses, where misunderstandings can have fatal consequences.

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[18] *Annual Report of the Governor of Porto Rico to the Secretary of War* (Washington: Government Printing Office, 1919), 85.

In his memoirs, physician Luis Guerra tells the story of how at the beginning of his career in the 1940s in Sahuaripa—a rural community in the border state of Sonora—he gave treatment to "father Cornidez." This local priest, a diabetic old man who grew up in the northern mountains, needed a daily injection. The pastor had decided that he personally would administer the insulin to himself. Doctor Guerra faced the trouble that father Cornidez was careless with the doses and "was never able to tell how many milliliters he injected into himself. When I asked him about the quantity he used he replied 'a little bit' and made a gesture whit the thumb and the index finger almost touching each other."[19]

Measurement and quantification are fixed traits in modern medicine, and they are carried out not only by surgeons and nurses in hospitals and clinics, but also by patients in their homes. Doctors ask patients to self-monitor their temperature, blood pressure, glucose, and so on, which requires learning to use several measuring devices. Parents are usually asked to take the temperature of their children (it is not rare that they even learn to use two or three different kinds of thermometers), and they are also expected to keep yearly records of the height and weight of their children. This means that a whole set of health-related measuring devices have become part of the domestic equipment found in modern homes: thermometers, scales, glucometers, yardsticks, and so on.

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[19] Luis Guerra González, *Andanzas rurales de un maletín* (Hermosillo: n.p., 1999), 73.

The Death of Measures

We have seen how state policies are a crucial element to succeed in the implementation of the metric system in two different ways: forcing people to use metric measures on a daily basis and eradicating the employment of customary units. But the state's impact was limited and the influence of certain key economic processes was needed to complete metrication.

Long distance trade (both among different economic regions within a country and among nations) and industrialization required a single set of measures to enhance its effectiveness, and both played an important role in metrication. It is not rare that the metric system advanced when industrial processes and mechanization replaced traditional forms of production. Machinery produces identical and standardized commodities, adjusted to dimensions that have to be regulated by precise measurements. Thus, as a great number of goods that were previously made in manually or with pre-industrial technology started to be massively produced, metric measures began to be more widely used. Let's see a few examples.

In the textile world, machinery to make thread and cloth that used the meter as its standard pattern arrived in Mexico in the late nineteenth century and replaced traditional handlooms and their corresponding customary measures. Laundresses used to charge per dozen items of clothing for hand-washing but nowadays modern laundries charge by kilogram. And almost the same happened in the commerce of the tortilla; when tortillas are handmade they are charged by the dozen, but in mechanized *tortillerías* (tortilla shops) tortillas are sold by kilogram. As always there are exceptions to this tendency, like the so called “tortillas de harina,” (flour tortillas made of wheat) which are produced and standardized industrially, and are sold in bags of one or two dozen in super markets. Broadly speaking, however, the use of machinery and industrial production has pushed along the use of metric measures.

Industrialization transformed the production, distribution and consumption of goods. As I mentioned in chapter three, before industrialization, many economic processes were carried out in small local markets in rural areas and bazaars.. In these economic settings there are no fixed prices. Informal credit is given, merchandise is not labeled or packaged, and there is considerable space for bargaining and negotiations on the quality and quantity of goods. Contrary to this, industrial processes require precise standards, as each product must be identical to the others—same amount and same quality. Each bottle of coke must contain 355 milliliters and every Twinkie must weigh exactly 50 grams. The size of these products cannot be bargained over; negotiation, if any, is reduced to the price—and even prices of those products tend to be standardized. When someone buys a can of beans there is no possibility of giving or asking for a *pilón* (a small amount of extra product given free to customers), a traditional practice that modifies the amount of the product while maintaining the price (many times this *pilón* was used to balance deceiving measurements). In this way modern industries, with their requirement for standardized measures, ousted practices where quality, weight, and measure of a sale could be modified.

Similarly, in rural regions of Mexico some projects of “modernization” and industrialization undermined customary measures. The measurement of land, for example, was affected by two major national projects: first, the demarcation and settlement of public lands during the Porfirio Díaz presidency; second demarcation of *ejidos* (shared communal land) distributed after the 1910 revolution. In both cases, surveyors equipped with modern theodolites determined in hectares a considerable extension of the national territory (and consequently property titles were written using metric units). On the other hand, industrial goods became increasingly used in agricultural processes, like chemical fertilizers, which were sold and distributed in kilograms or metric tons, forcing farmers to become familiar with these units.

Literacy campaigns, another public policy of the post-revolutionary governments, also had a positive effect in spreading the use of the meter. Hand in hand with the increase of the number of people with a formal education, literacy levels increased from the end of the armed conflict until the 1990s. By 1970, 70 percent of the population could read and write—This was double the 34 percent at the end of the revolution.[20] Since teaching the metric system has been a fixed element in the curricula of elementary schools (from the times of Benito Juarez to the present date), massive public education aided the metrication process considerably.

The combined effect of all these processes shows up in a census of units of measurement carried out by the federal government as part of the fifth agricultural census of 1970.[21] Unfortunately, data from this count was not as systematic and comprehensive

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[20] Federico Lazarín, "Las campañas de alfabetización y la instrucción de los adultos," *Revista Interamericana de Educación de Adultos* 3 (1995): 79-98.

[21] Dirección General de Estadística, *Unidades de medida regional. V censo agrícola-ganadero y ejidal, 1970* (Mexico: Secretaría de Industria y Comercio, 1973).

as that of the census carried out in the 1930s (discussed in chapter two), among other reasons because this new census did not consider units of length used by producers to measure their land and only gathered information on weights and measures of volume. Nevertheless, by comparing the 1930s and 1970s censuses two matters come to light: first, the number of units of weight and volume decreased slightly; second, the number of towns and communities in which customary measures were used decreased dramatically.

This let us see more clearly how non-metric measures in Mexico have been dying. Wherever customary measurement units are used they exist in virtually the same number as in colonial times (i.e. the number of different measures remains more or less the same). But what we may call the social "ecosystem" of measures, which supports the survival of customary measures, has been disappearing.

Nevertheless, non-metric measures have been extraordinarily resilient, and the reign of the metric system has not been uncontested.

An Exclusive Measurement System?

Those who brag that Mexico is today a fully metrified nation may change their minds upon hearinga carpenter asking for "a kilogram of one-inch nails" in any hardware store. There are numerous similar cases of products that are measured mixing multiple measurement systems. It is so natural to hear plumbers taking about "three meters of a half-inch pipe" that the metrological dissonance is almost imperceptible.

Considering the large number of exceptions to the exclusive use of metric units in everyday life, commerce and crafts, it would be more accurate to say that Mexico is a country where the metric system is *predominant* rather than exclusive. Not only do numerous customary measures persist in isolated communities, they are also present in urban areas and technical occupations.

In areas where the influence of the United States industry is intense the English customary system tends to be predominant. Graphic designers, for example, use fonts measured in *dots per inch* (DPI), but have to work with paper standardized in metric sizes. Jewelers use carats to determine the purity of gold and the mass of gemstones.[22] Economists forecast the growth of the economy considering the ups and downs in the price of oil barrels taking into account the fluctuation in the price of barrels of oil (with each barrel equal to 42 US gallons). Fashion designers set clothing sizes that are not always based on centimeters—and there is the fascinating case, at least in Mexico, of *sastres* (tailors) who measure men's clothing in inches, and *costureras* (seamstresses) who measure women's garments in centimeters.[23]

Daily life and small-scale commerce are even richer in adaptations and mingling of metrological systems. Intermediaries in the clothing business sell by *pacas* (hundred pieces) and *lotes* (160 pieces); gardeners sell potting soil by *costal* (sack); fruit sellers deal oranges by the *arpilla* (a kind of mesh bag) and strawberries by the basket. Feeding bottles for babies, even in Mexico, are graduated in ounces instead of milliliters,

[22] On the consequences of metrication to graphic design: Richard L.Hopkins, *Origin of the American Point System for Printers' Type Measurement* (Terra Alta, W. Va.: Hill & Dale Press, 1976).

[23] Claudia Rivera called my attention to this metrological discrepancy between tailors and seamstresses. She advanced the hypothesis that this divergence may have been originated by the incorporation of seamstresses into the textile industry.

something that made parents of small babies fluent in calculating portions using these non-metric units. It is interesting to note also how the dozen has survived in our decimal world, as it is present in the retail commerce of many products, such as flowers and eggs, just to mention two examples.

The kitchen is a weights and measures parade where exact sciences and millenary vagueness coexist pacifically. A modern cookbook (or the instructions printed on the back of a package of a pre-made chicken soup, for that matter) shows how many liters of water and grams of meat are required to prepare a stew, indicates the exact temperature in degrees Celsius for the oven, and specifies the number of minutes that it would take for the food to be cooked. Those are unambiguous instructions that can be followed by any cook in Veracruz, Tokyo, or Prague. Minutes, liters, kilograms, and degrees Celsius are global conventions, part of a universal language—something unthinkable prior to the nineteenth century, when the preparation time was measured by how many prayers had to be said before removing the meat from the fire. But also in the kitchen live, alongside the laboratory precision of the metric system, many inaccurate and nebulous units like a pinch, a handful, and a spoonful—non-standardized measures that produce insomnia in apprehensive spirits, fearing that an incomplete pinch of salt would leave a dish bland.

Today we continue to use different measuring methods based on experience, just as with ancient measures. For example, when guessing distances people do not always talk about kilometers, they rather relate time with a means of transportation—"it takes five hours by plane to arrive from Mexico City to Newark." Also, to measure large quantities of people, it is common to use stadiums or auditoriums as a measurement unit;

we say, for example, "the people who attended the demonstration could fill Madison Square Garden twice." The concrete and qualitative character of the old measuring units—which contrast with the abstract and quantitative nature of the metric system—has not abandoned us.

All in all, it is fair to say that no measurement system is ever exclusive. Not even in countries where the metric system has ruled for more than a century has it achieved complete exclusivity. Science and engineering, relatively closed fields with fast and effective means of communication, can be homogenized relatively quickly; but in daily-life routines it is much more difficult to set worldwide conventions, as the habits that shape everyday life change very slowly.

Measurement and Punishment

Students know that a school assignment that will be graded is completely different from one which will not receive any kind of grade—even if they know that the content of the assignment would be exactly the same. They are aware that the consequences of a "gradable" assignment are quite different from to those of a non-graded school task. Being mindful of this, they approach school chores in different ways. *When performance is measured it becomes a recordable piece of information,* and that numerical record can be stored, traced, compared, and tabulated. These measurements can result in rewards, but also in punishment. From very early on, people became aware that *measurement always has a purpose,* that things are measured for a purpose, and that there are no gratuitous measurements.

An indigenous community knows that when the government or a private surveying company starts measuring and delimiting communal lands—lands that up to that point no one has ever known exactly how big they are or where they start and where they finish—means that bad news is on the way. Surveyors are the first visible sign of a forthcoming enclosure—and the introduction of individual private property. Clocks, chronometers, and watches were instruments used to domesticate labor in factories at the beginning of industrialization. Since then workers have been aware that measuring means a more efficient form of exploitation.[24]

When scales replaced volume measures for dry products consumers in bazaars and markets very soon understood that the scale was a "devil's instrument," as they called it, which always give short measures—and there was little they could do about it, because scales were expensive and complicated instruments that very few could afford or maneuver which excluded them from a *de facto* monopoly on weighing instruments.[25] Not to mention all the trickery used by sellers to cheat costumers while operating the scales. It is no accident that scales are usually placed behind the counter, where costumers cannot see the scale in its entirety and where it is impossible for them to touch it or use it (in this regard today's scales in the middle of the supermarket for the use of costumers are a historical rarity, and a manifestation of the standardization of products).

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[24] See the classic study of E. P. Thomson, "Time, Work Discipline, and Industrial Capitalism," in *Customs in Common* (New York: The New Press, 1993), 352-403.

[25] See for example Julio de la Fuente, *Yalálag: una villa zapoteca serrana* (Mexico: Museo Nacional de Antropología, 1949), 136.

Not surprisingly one of the first antecedents of the Mexican revolution in the state of Morelos (homeland of Emiliano Zapata) was a strike of sugarcane workers who vehemently opposed the introduction of scales in *haciendas* (plantations). The laborers rejected the employment of weighing instruments because that would have meant a complete change in the way they were paid. Traditionally workers were disbursed following a system of *lías,* in which canes were measured in carts with a rope of a fixed number of *varas*, and laborers were paid by the number of "ropes" they completed. *Hacienda* owners wanted to change this method and start calculating the amount of sugarcane harvested by weight, using scales, but the opposition of workers in Morelos—suspecting an oncoming fraud in the measuring method—halted for several years the introduction of scales in that state.[26]

This was only one of the multiple forms in which the link between measurement, justice, and fairness manifests itself. Measurement, as Witold Kula noted, is *not a convention but a value*, and it is never neutral.[27]

2. THE MORAL ECONOMY OF MEASURES

In January 2007, in the midst of a global rising of prices of food stuffs—due mainly to scarcity of grains, which was in part triggered by the production of ethanol—

[26] Salvador Rueda Smithers, *El paraíso de la caña: historia de una construcción imaginaria* (Mexico: Instituto Nacional de Antropología e Historia, 1998), 171-172; Ángel Ruiz de Velasco, *Estudios sobre el cultivo de la caña de azúcar* (Cuernavaca: Imprenta del Gobierno del Estado, 1894), 66-68.

[27] Kula, *Men and Measures*, 17. For valuable historical study see Graeme J. N. Gooday, *The Morals of Measurement: Accuracy, Irony, and Trust in Late Victorian Electrical Practice* (New York: Cambridge University Press, 2004).

the price of corn and tortillas in Mexico rose significantly. The tortilla is the cornerstone in the deficient diet of 50 million Mexicans living below the poverty line. Uncertainty and worry spread rapidly among the population. Petitions for the government to take action and control corn prices were insistently voiced. Government officials found themselves in a predicament: if they ignored the food crisis the risk of social mobilizations or even violence could be high; but if they intervened directly in the market to restraint corn prices, they would break the two-decades-long commitment to neoliberal policies that prevent intervention in a supposedly self-regulated market.

The government performed two actions aimed at releasing some pressure from the corn price and to calm down popular anger, but without upsetting the market. First, they tried to crack down on grain speculators—an effective idea but not the one that could produce immediate and visible results. The second action was to launch a campaign of verification of the scales used in *tortillerías* (tortilla shops). This was a direct action, attacking the problem head on, against the last link in the chain of the corn market: the tortilla vendors, the ones who actually received the money from the hands of regular people.

Soon enough newspapers and television news shows started to report tortillerías being visited by weights and measures inspectors. Some were found in possession of fraudulent or malfunctioning weighing devices. According to figures given by the Federal Office of Consumer Protection, seven percent of the scales verified were faulty, weighing between fifty and three-hundred grams less per kilogram (i.e. five to thirty percent) in favor of the vendor. Vendors found guilty had to pay a fine of sixteen-thousand pesos (around fifteen-hundred dollars) and the scales were confiscated.

Many observers considered that this campaign was rather cosmetic; but it was somehow effective. The state was not able to grant what was considered a *fair price,* but it tried to guarantee *just measures*. Knowingly or not, the Mexican state struck a dormant but sensitive chord in peoples' collective beliefs about justice and fairness in the market place, its actions rang true with the idea of *moral economy*, an issue closely interrelated with measurement since long ago, as I will demonstrate.

Measurement and Fairness

The first systematic standardization of weights and measures was parallel to the invention of writing, arithmetic, and the emergence of the creation of centralized states in the Middle East; and with it was also born the symbolic association between measures and impartiality. Since then weights and measures have played an important part in the practice of fairness and in the imagery of justice.

An Egyptian *Tale of Woe* that describes a time of chaos and decay in a place suffering, a local tyrant, exorbitant taxes, arbitrary despotism, hunger, and rigged measurement practices describes this:

> His tax had been burdensome to me, more than can be imagined.
> Many have been those crushed by it and seized by him and the staff.
> He caused me to remain deprived of my corn, which other had given to me when he gone on his journey.
> The people said of his false grain measure:
> "How wicked is the carpenter that made it!

One sack becomes in it a sack and half."[28]

The Old Testament is very repetitive on its prohibition of tampering with weights and measures. Leviticus 19:35-36, "Do not use dishonest standards when measuring length, weight or quantity. Use honest scales and honest weights, an honest *ephah* [dry measure] and an honest *hin* [liquid measure]." Deuteronomy 25:13-16, "Do not have two differing weights in your bag—one heavy, one light. Do not have two differing measures in your house—one large, one small. You must have accurate and honest weights and measures, so that you may live long in the land the lord your god is giving you. For the lord your god detests anyone who does these things, anyone who deals dishonestly." Proverbs 11:1, "The lord abhors dishonest scales, but accurate weights are his delight." Proverbs 16:11, "Honest scales and balances are from the lord; all the weights in the bag are of his making." Proverbs 20:10, "Differing weights and differing measures—the lord detests them both."

According to Flavius Josephus' *Jewish Antiquities,* Cain—son of Adam and Eve, brother of Abel—"settled with his wife at a place called Nod, where he had children; indulging in every form of vice and violence, he grew rich and ended the simple life by inventing weights and measures."[29]

In the New Testament Jesus of Nazareth commands "Give, and it will be given to you: good measure, pressed down, shaken together, and running over, will be given to

[28] Quoted in Jan Assmann, *The Mind of Egypt: History and Meaning in the Time of the Pharaohs* (New York: Metropolitan Books, 1996), 292-293.

[29] Flavius Josephus, *Josephus: The Essential Writings* (New York: Kregel, 1990), 21.

you. For with the same measure you measure it will be measured back to you." (Luke 6:38).

It is not necessary to pile up here more examples from Antiquity to illustrate that fairness and measurement have been liked for centuries (in fact, it is no accident that today court buildings have at their front a sculpture of *Justice,* a blindfolded woman bearing a sword and a balance in equilibrium).

The idea that weights and measures were invented by Cain or by some diabolic entity was still considered to be true in eighteenth-century England. It was something discussed in literary circles and believed by the crowds. These ideas and the hatred towards short measures frequently prompted them into action.

For example, in 1753, in Tauton, at a time of restrictions in food supply due to exportation of grain, a crowd of five hundred men and women complained that milk was "sold by small measure," destroyed the pails, and moved "to settle scores with local millers."[30]

Measurement is an integral part of the moral economy of the crowd—a concept made famous by E. P. Thompson—especially in times when the money economy does not exist or is not prevalent. Thompson did not underline the importance of weights and measures, even though he left some clues pointing in that direction. He showed the tensions and contradictions between the "paternalist model" that informed the moral

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[30] Richard Sheldon, Adrian Randall, Andrew Charlesworth, and David Walsh, "Popular Protest and the Persistence of Customary Corn Measures: Resistance to the Winchester Bushel in the English West," in *Markets, Market Culture and Popular Protest in Eighteenth-Century Britain and Ireland,* ed. A. Randall and A. Charlesworth (Liverpool: Liverpool University Press, 1996), 27.

principles of the peasants and the logic of the free market economy. The paternalist model indicated that

> The farmers should bring their corn in bulk to the local pitching market; they should not sell it while standing in the field, nor should they withhold it in the hope of rising prices. The market should be controlled; no sales should be made before stated times, when a bell would ring; the poor should have opportunity to buy grain, flour, of meal first, in small parcels, *with duly-supervised weights and measures.*"[31]

In 1768, in Tetbury, England, demonstrations and riots erupted against the imposition of the Winchester bushel, when the British Crown tried to unify the territory under the London measures. One day a traditional bushel of the town (which contained one gallon and a half more than the Winchester bushel) was adorned with trophies, ordered into the market with trumpets and bells, conducted to the church, and received "the acclamation of all orders and degrees of men, regular and secular." That same year, in Tewkesbury, people publicly burned Winchester bushels and bakers were accused of buying by the large measure and selling by the small one.[32]

Thompson describes an act of popular resistance in 1795 against the change of grain measures from a nine-gallon to an eight-gallon bushel; a change that in practice meant that people paid the same amount of money for less grain—besides the problems in calculations due to the change of units that usually confused poor people. Thompson concludes that "the arithmetical notions of the poor may not have been so erroneous.

[31] E. P. Thompson, "The Moral Economy of the English Crowd in the Eighteenth Century," in *Customs in Common: Studies in Traditional Popular Culture* (New York: The New Press, 1993), 193. Emphasis added.

[32] Sheldon *et al.*, "Popular Protest and the Persistence of Customary Corn Measures," 37.

Changes in measures, like changes to decimal currency, tend by some magic to disadvantage the consumer."[33]

Destruction of metric weights and measures occurred in France. Ken Alder describes how in 1840—when the French state made its second and definitive try to impose the mandatory use of metric units[34]—a group of dockworkers in Clemency "smashed decimal measures, and the government had to call in the cavalry." The riot was initiated due to suspicions that the change of measure would affect the workers and open the town to harmful competition. That same year in France this chorus of song started to be heard in the streets:

Ce n'est pas d' nos faiseurs de lois	I'm not fan of our legislators'
L'système	Decimal
Décimal que j'aime.	Systemical.
Viv' les mesur' d'autrefois!	Long live the measures of yesteryear!
Au diabl' les nouveaux poids.	And damn the new weights and measures![35]

Witold Kula described that while Savoy and Piedmont were ready for the metric reform ordered by the king in the 1845, in Sardinia peasants obstinately adhered to their customary measures, "either out of traditional attachment or because they could not

[33] Thompson, "The Moral Economy," 218.

[34] The first campaign of metrication went from 1795 to 1812.

[35] Quoted in (and translated by) Ken Alder, *The Measure of all Things* (New York: The Free Press, 2002), 329, 393. For other cases of metric opposition in France see Gustave Tallent, *Histoire du Système Métrique* (Paris: Libraire H. Le Soudier, 1910), 88-95.

afford—in the wake of a poor harvest—to acquire new [standards],” and rioted against the introduction of the metric system in 1848.[36]

As we can see from these examples, it is not rare that for people the substitution of a familiar and functional system of measurement with a new one, especially when that substitution comes from outside, is usually problematic and it can spark explosive reactions. This was precisely the case in one of the few documented violent actions of opposition against the metric system in Mexico.

Juquila versus the Metric System

> The Zlotogrod District lay in the remote eastern part of the monarchy, a region in which there had previously been a worthless Inspector. A long time ago—the older ones could still remember it—there had been real weights and measures! Now there were only scales. Only scales. Cloth was measured with the arm, and as all the world knows, a man’s arm, from his closed fist to his elbow, measures an ell, no more and no less. Moreover, all the world knew that a silver candlestick weighed a pound and twenty grams, and a brass candlestick about two pounds. Indeed, in those parts, there were many folk who really had no use for weights and measures. They weighed in the hand and measured with the eye. It was not a propitious district for a public Inspector of Weights and Measures.[37]
>
> *Joseph Roth*

In modern societies, where money is the fundamental instrument for economic transactions and where the millenary dream of standardized and exact measures has been achieved, it is difficult to recognize the symbolic and material relevance of weights and

[36] Kula, *Measures and Men*, 275.

[37] Joseph Roth, *Weights and Measures* (London: Peter Owen, 2002), 11.

measures; nevertheless this is a latent issue that from time to time comes to the fore—even though not with the same energy as it did in the past. The successful imposition of the decimal metric system in Mexico (and around the world) has tamed many of the contentious elements of measurement. However, the introduction of metric measures into everyday life—beyond bureaucratic offices, scientific labs, and industrial factories—was a complicated enterprise. A perfect illustration of this can be found at the end of the nineteenth century, at the very beginning of the introduction of the metric system in the country, in a small southern town where the metric system—and all the policies around it—became a matter of life and death.

Juquila is a small town in the southern state of Oaxaca, in Mexico. It is the municipality of a region of Chatino Indians. Anthropologists studying the oral history of Juquila have collected stories of the community. One of the most curious is what they called "The War of the Pants," an episode almost forgotten today, even though it reached international attention at the time.[38]

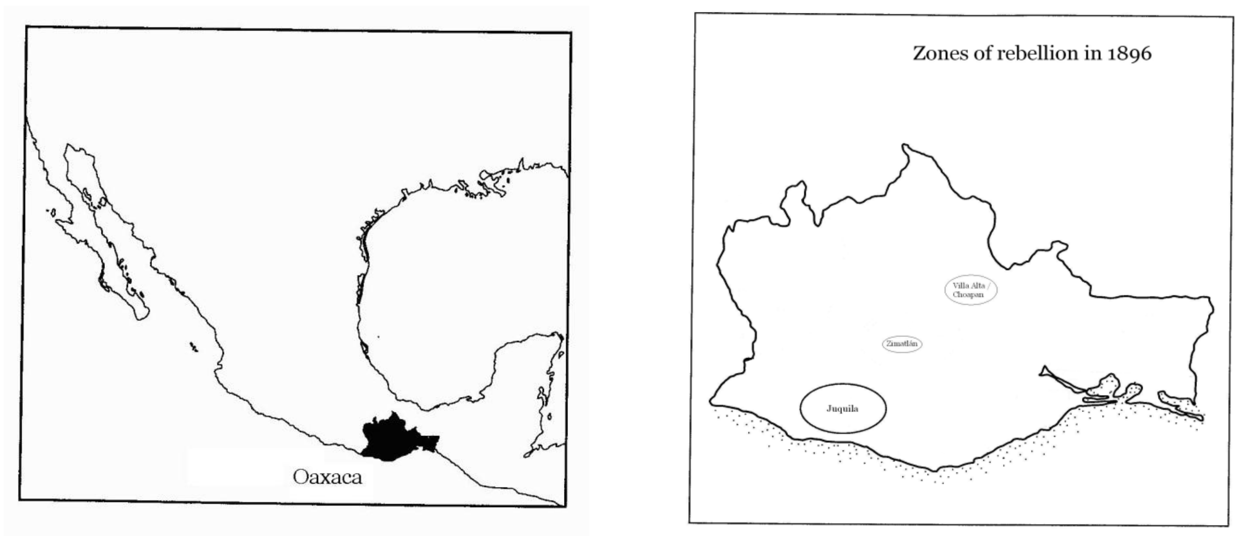
[38] Contemporary accounts of this conflict can be found in the national newspaper *El Universal* and in the statewide newspaper from Oaxaca, *La Libertad;* also in Cayetano Esteva, *Nociones elementales de geografía histórica del estado de Oaxaca* (Oaxaca, Tip. San Germán Hnos, 1913), 466-467. For recent studies by historian and anthropologists see Franco Abardía y Leticia Reina, "Cien años de rebelión," in *Lecturas históricas del estado de Oaxaca. Volumen III: Siglo XIX,* ed. María de los Ángeles Romero (Mexico: INAH, 1990), 484-489; Miguel A. Bartolomé and Alicia M. Barabas, *Tierra de la palabra. Historia y etnografía de los chatinos de Oaxaca* (Mexico: INAH, 1982), 40-43; Francie R. Chassen López, *From Liberal to Revolutionary Oaxaca: The View from the South, Mexico 1867-1911* (University Park: Pennsylvania State University Press, 2004), 370-377; James B. Greenberg, *Santiago's Sword: Chatino Peasant Religion and Economics* (Berkeley: University of California Press, 1981), 47-51; James B. Greenberg, *Blood Ties: Life and Violence in Rural Mexico* (Tucson: The University of Arizona Press, 1989), 184-192; Héctor Gerardo Martínez Medina, "La ley de hacienda y la rebelión de 1896," *Guchachi' Reza* 43 (1994): 22-31; and Leticia Reina Aoyama, *Caminos de luz y sombra. Historia indígena de Oaxaca en el siglo XIX* (Mexico: CIESAS, 2004), 210-214.

In its edition of April 14, 1896 *The Washington Post,* reported this news from Mexico:

> Murdered by Indians: Drunken Redskins Kill Officials of a Mexican Town
>
> A telegram from Oaxaca City this afternoon states that the rebel Indians at the town of Juquila killed all the town Councilors, school teachers, local priest, Chief of Police, and the telegraph operator, in fact, every one holding a government place. The people are in terror and troops have been sent for the relief of the town… [The Indians] began their plotting in holy week, instigated by Indian lawyers, who informed them that the new State taxes were unconstitutional, but the authorities paid no attention to the excitement among them, considering they were engaged in their usual drunken celebration of the season. But procuring arms and machetes, they made a rush for the town hall and the prefect hastily closed the doors, which they soaked with petroleum and burned, thus effecting an entrance, sacking the place and penetrating the apartments of the prefect, glossy maltreated the women of his family, and then turning the attention to the officials and armed servants, killed and wounded several.
>
> The scene was a horrible one, as the assault took place in the early evening, and the excitement of the mob was indescribable. The Indians were possessed with fury, and it was absolutely impossible for respectable inhabitants to control them, as all were drunk and maddened…

Where are the pants in all this? When the Indians entered into the town, they were shouting "death to all who wear pants," in reference to the mestizos and whites who used European-style clothing. The authorities regained control of the district capital a couple of weeks later, after the governor dispatched the army's Fourth Battalion to the region. The newly appointed prefect declared that to enter the towns under his jurisdiction people could not be wearing indigenous dresses. Indigenous women's blouses (*huipiles*) and rough cotton tops and bottoms (*camisa* and *calzón de manta*) were forbidden. Hence merchants loaned pants, shoes and jackets to the Indians who needed to go to the town markets.[39]

Figure 13. Zones of Rebellion, Oaxaca, 1896



Conflicts and social unrest occurred also in at least two other districts of Oaxaca. These revolts lasted only three weeks, but received attention in the national newspapers and public opinion. In 1901 the lawyer and sociologist Julio Guerrero published what would become the influential study *The Genesis of Crime in Mexico: An Study on Social Psychiatry.* In his book Guerrero recalled the events in Juquila calling attention to an important fact (actually the element that makes the Juquila rebellion pertinent to the

[39] Chassen López, From Liberal to Revolutionary Oaxaca, 1, 370-377.

history of the metric system) and provided more gloomy details on the incidents in Juquila:

> In April 1896, the Indians who had rebelled against the new metric system law—instigated by some stupid *tinterillos* [inept lawyers]—arrived in Juquila, taking its inhabitants by surprise. The crowd freed the prisoners from the local jail and all advanced together to confront the local authorities. When the town's *jefe político* [prefect] faced them to restore order the Indians asked him to relinquish the town and church monies. When he refused to do so, a number of rebels started searching for Núñez, the town's foreman. As soon as they found him a black man wounded him with a machete; Núñez escaped and sought shelter at Octaviano Gijon's house, a well-respected person in the community and former *jefe político*. Gijón tried to calm down the insurgents, but they attacked him with machetes, sticks, and stones. Gijón's son, Reginaldo, ran to help his father, but both were ripped apart with machetes. Meanwhile, other rioters literally *tore up* Núñez and destroyed the house. The bloody and loudly mob moved quickly to Octaviano Gijon's oil factory; there they killed Mr. Rafael Parra alongside four other workers, and stole mules, horses, pigs, and chickens. Afterwards the Indians walked to Federico Gijón's place, killed Carlos Morales, and pillaged his house as well as Feliciano Sánchez's—who was shot down in the backyard. They killed the girls' teachers as well. The telegrapher defended his office with a gun, but he was killed, beheaded, and his head was put on a pike and dragged through the streets. The mob appointed a new town counselor and forced him to send a letter to other towns in the district to collect money, horses, and supporters. Finally, the rioters piled up four thousand *quintales* of coffee [aprox. 400,000 pounds] in the main square and used it as a pyre to burn the bodies of Don Octaviano Gijón and thirty-two other victims. As the grains of coffee were set on fire, the Indians laughed and shouted profanities. More than one thousand bandits left for the hills carrying rifles and machetes. The gang walked along the bluish and exciting fumes produced by the burned coffee. The threads of smoke interweaved with the white

> shirts of the assassins and their mahogany bodies, and between the legs of the mules that climbed up the paths loaded with the bloodied bundles of pillage.[40]

This was all that Guerrero said about Juquila. His depiction was part of a section of his book with examples illustrating what he called "the trivial circumstances that trigger deadly crimes in Mexico." He wanted to show how something as banal as the metric reform produced such a ferocious reaction. Guerrero took all the information from national newspapers. Despite his morbid tone, the details in his narrative are not contradicted by contemporary reposts or by later reconstructions made by historians and anthropologists. The problem with Guerrero's description, however, is that he was extremely selective in choosing the specific details included in the narrative. His omissions and lack of context hide important facts that are essential to make sense of the actions of the rioters and to frame their opposition to the metric system into a larger picture of resistance against—and negotiation with—the liberal reforms made by the Mexican state of that period.

Unfortunately we lack a description of the events in Juquila made by the people participating in the uprising, although some of the victims provided information to newspapers. As happens frequently with popular movements prior to the twentieth century the Juquila rebels left some footprints in history, but not a full account told from their own perspective. To make sense of their actions we can only critically read the

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[40] Julio Guerrero, *La génesis del crimen en México. Estudio de psiquiatría social* (Mexico: Consejo Nacional para la Cultura y las Artes, 1996), 193-194.

reports made by whites and dig into the historical context. We need to assemble a sort of "interpretation through contextualization."

Using Julio Guerrero's text as a starting point, we can flesh out what happened in Juquila by explaining the significance of some of the elements included in his description, and bring attention to what he suppressed.

Elements present in Guerrero's depiction:

*Coffee***.** It is no coincidence that two of the pioneers in the cultivation of coffee in Oaxaca were Mexico's president and the Oaxaca-native, Porfirio Díaz, and Matías Romero (the representative of Mexico in the Inter American Conference in Washington who supported the Pan-American adoption of the metric system). Production of coffee in Mexico—concentrated in the states of Veracruz, Chiapas and Oaxaca—was part of the transformation of Mexican agriculture to fit into international markets and take advantage of the sudden increase in the demand for coffee in Europe and the United States. It was the production of coffee that triggered the arrival of non-Indigenous Mexicans and Europeans to the Juquila area to open large plantations—at the expense of Indigenous communal lands. At the same time, the growing interest for the bean worldwide fitted in well with the needs of the Chatinos, who suffered from a steady decrease in the demand for cochineal (a natural carmine dye used in silk and wool) in the international market, due to the invention of synthetic coloring. Coffee was then not the first but the second generation of cash crops which had replaced the production of subsistence crops in Juquila and other parts of Oaxaca in the second half of the nineteenth century. But this was the first time that these apparently isolated communities had to react to the shifts in international prices and adapt their production to the unstable market of global commodities.

*Tinterillos***.** It is not clear who the so called *tinterillos* (inept lawyers) were. One possibility is that they were Indigenous lawyers (probably without legal training) who sold their services to other Indigenous people. Since at that time eighty percent of the population in Oaxaca could not read or write, peasants needed *tinterillos* for every official procedure, like the payment of the newly established small property taxes. But chronicles of the events emphasize that *tinterillos* incited the population to protest against taxes. These instigators may well not be simple lawyers, but actually some of the leaders of the concurrent revolts in Zimatlán and Ocotlán, regions where conflicts exploded a week earlier than in Juquila, and who are believed to have found refuge in Juquila when they were escaping from state authorities. According to some accounts, these individuals were actually the heads of the movement in Juquila.

Octaviano Gijón. It is no accident that Gijón was the first fatal victim of the day in the Juquila uprising or that the rioters decided to kill his son and loot his factory. Seven years earlier (in 1879), when Gijón was *jefe político* (prefect), he had sent several Indian leaders of the Chatino community of Quiahije to jail; and he was also remembered for the military repression of a protest against the imposition of a head tax in 1881. Now, in 1896, on the occasion of a newly created tax, many people from Quiahije were present among the rebels. This time the Indians took action against Gijón before he was able to ask for help from the military.

Elements absent in Guerrero's description:

Taxes and land property. The liberal reforms enforced by the Díaz regime aimed at the destruction of colonial and Indigenous institutions, both economic and political. The Indigenous communal property of the land, which remained during the three centuries of Spanish colonial rule, was replaced by individual and private property since the 1850s. The political status of the Indigenous as communal entities (or *pueblos*) was transformed by the birth of universal citizenship. As citizens, the Indigenous became subject to all taxes (before they were granted citizenship, pueblos had to pay a high but fixed duty). The new real estate tax for small property was designed to eliminate the intern tariff for commerce within the country (the colonial *alcabalas*), in order to aid the creation of an effective national market and help economic integration in the country without losing state revenue. In this connection, the metric system was an instrument to destroy the Indigenous and colonial weights and measures, which local variations and lack of standardization created numerous problems for commerce among different economic regions. In fact the elimination of *alcabalas* and the substitution of customary measures for metric ones had parallel trajectories: both plans became law in 1857, with the liberal government, and both plans were not enacted until 1896 during the Díaz regime.

Pants and catrines. Even though the "War of the Pants" is mostly remembered as a "tax revolt," ethnic discrimination played an important role in the conflict. Surely the mob in Juquila was very violent, but that violence had very specific recipients. The battle cry of "Death to all who wear pants!" was unmistakably directed at foreigners. Alongside Octaviano Gijón, all people killed were whites and mestizos, persons who arrived at

Juquila to enclose communal lands, introduce new crops, impose new taxes, and force Indigenous people to work as agriculture wage laborers. Even if the Chatinos acted against those who they identified as *catrines* (the fancy dressers), this was not a "fashion war." Fashion, however, was an ethnic marker that served rioters to target their enemies. The *catrines* had their revenge by forcing Chatinos to wear pants once the rebellion was suppressed. Some historians have interpreted the imposition of this clothing code as a strategy of whites and mestizos to erase the most visible difference between ethnic groups and prevent new selective killings. However, the imposition of pants on the late - nineteenth century natives was actually a wide spread policy throughout the whole country—before and after the War of the Pants.

For example, in Carl Lumholtz's famous book *Unknown Mexico* there are very similar elements to the etiquette policy imposed in Juquila in the aftermath of the rebellion. As Lumholtz recalled:

> …early in the afternoon we arrived at Tepic after a journey of six days and a half. My men, both Mexicans and Indians, had been much worried about their entry into the city, because the law of the Territory forbids anyone to appear in the streets of the towns without pantalones (trousers). This law, in operation in one or two of the States of Mexico, is intended to promote culture by improving the appearance of the natives. It is argued that the loose white cotton drawers (calzones) worn by the working classes and the civilised Indians are not decent enough. […] Visitors not up to date are given an opportunity of buying trousers after they get into town. But woe to the one who should linger too long about the streets without the prescribed attire! He would be promptly arrested and condemned to pay a fine amounting to more than the cost of the garment. To be sure, trousers may be bought very cheap, or may even be hired for the day. There are here in Tepic some enterprising speculators who rent them […]. Muleteers visiting towns

periodically generally carry this requisite property of civilisation with them and array themselves duly before entering.[41]

This civilizing character trusted to the pats by the Mexican elites can be reaffirmed by episodes like this one described in John Kenneth Turner's *Barbarous Mexico*:

> When Elihu Root went in to Mexico to see Diaz and to arrange some matters in regard to Magdalena Bay, Diaz was desirous of showing Root that the Mexican people were not as poverty-stricken as they had been painted. He therefore, through his Department of the Interior, distributed the day before Root's arrival in the capital, 5,000 pairs of new pantaloons among that class of workmen who were habitually most prominently on the streets. In spite of orders that the pants were to be worn, the majority of them were promptly exchanged for food, and so Mr. Root was probably not very badly fooled.[42]

In general, from the 1880s to the beginning of the 1910s, in places as varied as San Luis Potosí, Colima, Jalisco, Nayarit, Mexico City, and Oaxaca, pants became a mandatory garment—even though the success of these official dispositions was pretty low.[43] In no other place did pants become such a contentious issue as in Juquila; but the plan to force Native Mexicans into the use of pants was much more than an eccentric and defensive strategy of local politicians in Oaxaca.

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[41] Carl Lumholtz, *Unknown Mexico: A Record of Five Years' Exploration Among the Tribes of the Western Sierra Madre; in the Tierra Caliente of Tepic and Jalisco; and Among the Tarascos of Michoacan* (New York: C. Scribner's Sons, 1902), 289-290.

[42] John Kenneth Turner, *Barbarous Mexico: An Indictment of a Cruel and Corrupt System* (New York: Cassell, 1912), 271.

[43] Moisés González Navarro, *El Porfiriato. Vida social* (Mexico: Hermes, 1974), 396-397.

But let's go back to Juquila. What was the end of it all? A report published in the *New York Times* gives us a concise answer:

> Mexican Troops Killing Indians
>
> Punishment for Participants in the Juquila Uprising
>
> The Federal troops rapidly are killing the Indians who rebelled against the State authorities. Twenty-five participants in the uprising have been shot by official orders at Juquila and over 100 Indian prisoners have arrived [to Oaxaca city] for trial. They all will be shot.[44]

In fact not all of them were shot in the state capital. On their way to the city from Juquila, soldiers shot one out of every five prisoners. The rest were deported to the state of Quintana Roo or conscripted into the army.

Despite the military operation that suppressed the rebellion, the revolt was successful in two of its objectives: first, the local congress eliminated those articles regarding taxation on small land property from the legislation; second, the governor banned the teaching of the metric system in the curriculum of public elementary schools located in the regions where the conflict took place[45] (significantly, modern historians have overlooked this second aspect).

Although the events in Juquila may look at first glance like a compulsive reaction of peasants who just wanted to preserve their customs and traditions from an "external"

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[44] *New York Times,* May 11, 1896.

[45] Archivo Bertely, doc. 17, in Archivo General de Oaxaca 15, VIII, 1896, quoted in María Bertely Busquets, "Panorama histórico de la educación para los indígenas en México," in *Diccionario de historia de la educación en México,* ed. Luz Elena Gaván Lafarga (Mexico: CIESAS, 2002).

intervention, the reality is that the relationship between Chatinos, foreigners, and the state and federal authorities was far more complex. This was not a simple confrontation between an archaic and untouched culture and Westernizing whites. The Chatinos were never an isolated community, pristine and uncontaminated by the outside world. They had had to adapt to changing conditions, first under colonial rule, then as part of the independent nation (and only 15 years later after the revolt, people in Juquila saw Emiliano Zapata with thousands of peasants wearing rough cotton rags entering the town in the midst of a national revolution).

The events of 1896 in Juquila were the consequence of a series of global, national, and local processes. The international fluctuation of commodities (like cochineal and coffee), the integration of Mexico into those markets (through international agreements that included the adoption of the metric system), the formation of a functional modern state (with an effective army), the rapid implementation of liberal policies (like a new taxation system and changes in the form of land property), the integration of economic regions in Mexico (thanks mainly to the construction of the railway system), and the local dynamics among whites, mestizos and the Indigenous community, are all conditions that had to be considered to understand the actions of the so called "drunk and maddened redskins" of Juquila.

How does the metric system fit into this revolt? Why did the Chatinos oppose the new units of measurement?

In 1897, a year after the national metric legislation was passed, the federal Minister of Development asked the governor of Oaxaca why there was no visible progress in the use of the metric system in that state. The governor replayed saying that

> We have not been able to make everybody in the state to be respectful of the metric legislation, but at least people in the larger towns are already using the metric units. However, in the smaller communities—the majority in the state—live the indigenous race, which cannot evolve quickly and does not have the resources to obtain the new weights and measures.[46]

Those small communities in Oaxaca were indeed very tenacious in clinging to their weights and measures. A national census of measures made in the 1980s—a full century after the War of the Pants—showed that in the municipality of Juquila some coffee producers still used traditional weights and measures, like the *quintal* (a unit used in Guerrero's description), that when employed to weigh "café oro" equals 225.7 kg and when used for "café pergamino" equals 180.8 kg (a 20 percent variation between one *quintal* and the other). Not only did the unit of measurement survive, but so did the very lack of standardization that drove economists and bureaucrats crazy in the nineteenth century.[47] How did these units of measurement continue to exist in the context of an almost fully metricated country? If Juquila followed the same path that other regions in Oaxaca did, the Chatinos learned to talk a metrological bilingualism. When interacting

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[46] Letter from August 21, 1897, AGN, Pesas y medidas, box 114, exp. 1.

[47] Instituto Nacional de Estadística, Geografía e Informática, "Equivalencias de unidades de medida regional," in *VI censo agrícola-ganadero y ejidal, 1981. Encuesta de rendimientos y equivalencias* (Mexico: INEGI, 1989), 253.

with the “outside world” they use the metric system, and when commerce is circumscribed within their own communities, they use traditional measures.

When Bronislaw Malinowski and Julio de la Fuente studied a market system in Oaxaca in 1940, he explained why peasants prefer to use the traditional measures:

> The Mexican government has been, for some time past, exercising a more or less persistent, and at times energetic, pressure for the general introduction of the metric measures. So far, success has been limited; indeed, in some ways it complicates the picture and introduces one more element of confusion and elasticity in the standard of comparison [for maize prices]. From the point of view of the whole system of maize marketing, this usually means that the poorer and less educated or less keen market agent is exploited by one who can manipulate figures, as well as measures, more rapidly and skillfully, and who has the whip hand of more capital at his disposal. […] The poor Indian and peasant prefer the *almud* [a traditional measures of grain], not because they are “conservative” or “dislike innovations,” but because this measure enters into all their domestic calculations in a manner which has been standardized for centuries, and they are accustomed to calculate with it. Thus, they know how many tortillas can be produced from one *almud,* of how many cups or bowls of *atole* (maize drink); in short, how many *almudes* per week their budgets require.[48]

Here Malinowski and De la Fuente described succinctly some of the economic and cognitive implications to metric change. Metric units are not easy to use, their magnitudes are alien to people used to calculate quantities in non-metric measures, and the decimal (10-base) progression that coordinates the units and its subdivisions is very different to the arithmetical logic of 12-base, 16-base, and 60-base that is used in almost

[48] Bronislaw Malinowski and Julio de la Fuente, *Malinowski in Mexico: The Economics of a Mexican Market System* (Boston: Routledge, 1982), 176; also of interest in this context: Roberto J. González, *Zapotec Science: Farming and Food in the Northern Sierra of Oaxaca* (Austin: University of Texas Press, 2001), 73-80.

all pre-metric systems. The metric system interfered with everyday thinking and sellers took advantage of that to cheat buyers (there are in fact numerous reports, from all over the country, just after the metric system became compulsory in the 1890s, of merchants who sold "pounds" of 400 grams, instead of the official weight of 460 grams per pound, benefiting from the disorientation of people who were just starting to familiarize themselves with the kilogram). This "cognitive noise" produced by an abrupt change in economic standards is not rare—as was recently seen in Europe with the introduction of the euro, for example.

In the case of the Juquila revolt this cognitive problem with the metric system was not only present in the commerce of grain, but also in the measurement of the land. The taxes on small property that triggered the revolt were determined according to the number of hectares of every plot of land. For the Chatinos, to pay a new tax was a problem in itself, but to determine the amount of money to be paid using incomprehensible measures—measures that open the door to all forms of trickery—was simply too much.

Mesuroclasts: Juquila and the *Quebra-Quilo* Revolt

There are not many nineteenth-century anti-metric revolts actually documented to contrast them to what happened in Juquila. However, there was one in Brazil that has significant similarities with the events in 1896 in Oaxaca.

In a three-month span (from November 1874 to January 1875) in numerous towns and villages in Northern Brazil, rioters entered local markets and smashed kilogram weights, which had been recently introduced in everyday economic transactions due to a new emphasis from the central government to enforce the years-long ignored metric legislation. Besides the destruction of *quilos* (kilograms), protestors prevented people from paying taxes, refused to answer census questions, and systematically destroyed records in tax offices, town halls, and notarial registers. Tensions and confrontations were frequent and some episodes of violence were documented. Because of the destruction of metric weights and measures, the movement was called by contemporaries *Quebra-Quilo* ("smash the kilos.")[49]

The destruction of metric measures was so systematic that it removed any suspicion that the destruction of scales and weights may have been accidental or secondary in the rioters' intentions. Kim Richardson has described what the Brazilian rebels did in some towns to break the new measures.[50] In Fagundes the rioters made groups of fifty to two-hundred to search and destroy metric weights and measures in the market and forced the police commander to sign an agreement to end the new taxes and the application of the metric system. In Ingá and Areia they not only destroyed scales, weights, and measures, but threw them into the forest alongside tables, benches, and other objects from the market. In Vitória rioters armed with pistols and knives attacked those sellers who used the metric system. In other places not only market sellers, but

[49] On the Quebra-Quilo revolt see: Roderick J. Barman, "The Brazilian Peasantry Reexamined: The Implications of the Quebra-Quilo Revolt, 1874-1875," *Hispanic American Historical Review* 53 (1977): 401-424; Armando Souto Maior, *Quebra-quilos: lutas sociais no outono do Imperio* (Sao Paulo: Companhia Editora Nacional, 1978); María Verónica Secreto, "Sem medida: revoltas no nordeste contra as medições imperiais," Paper presented at the Anais do V Congresso Brasileiro de História Econômica, September 7, 2003; Kim Richardson, "Quebra-Quilos and Peasant Resistance: Peasants, Religion, and Politics in Nineteenth-Century Brazil," PhD diss., Texas Tech University, 2008.

[50] Richardson, "Quebra-Quilos and Peasant Resistance," 28-33.

town businesses, taverns and butcher shops were deprived from their newly acquired metric standards, and the mob threatened to return if they continued using liters and kilograms. At Alagoa three-hundred rioters destroyed the decimal measures and demanded the models of the scales from the local authorities. In Alliança and Rio Grande do Norte merchants who refused to hand over their weights were badly beaten. At the market of Quebrangulo, where sellers unsuccessfully resisted a group of three-hundred rioters, the rebels destroyed the measures, killed ten persons and wounded some more.

Peasants in this Brazilian region faced conditions produced by a nationalscale liberal reform similar to those suffered by people in Juquila: new taxes, changes in land tenure, introduction of cash crops (cotton in the Brazilian case), and a metric reform. Their reaction was similar also (though with different degrees of violence): burning of archives and records, opposition to the metric system, defense of previous existing forms of land property, and deadly violence. The response by the state was the same in both cases: military repression and compulsory military conscription. Unfortunately in neither case do we have firsthand accounts of the events carried out by the rebels, something that has limited our understanding of their actions.

The people who participated in the revolts in Juquila and northern Brazil fit in part the description of what Eric Hobsbawm called "primitive rebels," pre-political groups who have not yet found a specific language in which to express their aspirations and demands, people who have not been born into capitalism, but capitalism came to them from the outside by the intervention of forces that they do not understand or control.[51]

Fortunately for researchers interested in historical metrology, the revolt in Brazil was remembered with the name of "Quebra-Quilo." With such an unmistakable label, historians have paid attention to the metric reform when studying the rebels' actions. Had they been labeled "Record-Burners," probably the whole movement would only have attracted the interest of historians working on the social effects of literacy, and the whole metrological dimension would have been forgotten. With the Juquila rebellion, remembered as the "War of the Pants" (instead of the "War of the Hectares," for example) modern researchers have systematically ignored the metrological dimension, focusing only on the taxation and ethnic aspects of the problem.

A limitation in the historiography of social movements is that scholars have not recognized the conflicts over weights and measures as a legitimate issue of popular protest. Even historians who have worked on the Quebra-Quilo revolt try to downplay this. For example, Gerald Michael Greenfield says that the Quebra-Quilo was "a disturbance in the Northeast ostensibly prompted by an attempt to introduce the metric system, but more recently has been interpreted as representing a *more fundamental social protest*."[52] And Richardson believes that "Although the authorities would label this revolt the Quebra-Quilo in reference to the metric system, the reality was that this was *first and*

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[51] Eric Hobsbawm, *Primitive Rebels: Studies in Archaic Forms of Social Movement in the 19th and 20th Centuries* (New York: Norton, 1965), 2-3.

[52] Gerald Michael Greenfield, "Migrant Behavior and Elite Attitudes: Brazil's Great Drought, 1877-1879," *The Americas* 43 (1986): 71. Emphasis added.

foremost a tax revolt."[53] I consider these interpretations to be shortsighted by presentism. Since we live in a successfully standardized world, weights and measures are barely a problem for us, and we tend to think that they were not a problem for people in the past either. But we should bear in mind that in pre and early modern societies taxes were frequently paid in kind, and peasants who worked as wage laborers received part of their payment in cash and part in kind, and all payments in kind were gauged in standards of measurement that were often tricked (always favoring tax collectors, merchants, and land owners).

Contemporary historians and anthropologists who have studied the Juquila rebellion have completely ignored the fact that part of the fight of the Chatinos was to reject the metric system—even though this was an element often mentioned by contemporary observers. How many other movements and social conflicts related to measurement have been ignored? More precisely, in how many social conflicts where metrological contempt has played a part in a larger set of issues has this particular dimension been overlooked by historians? My guess is that with a more acute focus we would find hundreds of such conflicts.

A contemporary historian who faces a conflict regarding religion and gender discrimination would not fail to recognize *both* issues, as important because we are sensible to these topics. However, when we see conflicts on taxation and measurement,

[53] Richardson, "Quebra-Quilos and Peasant Resistance," 13. Emphasis added.

we have failed to consider both elements on an equal footing, downplaying or simply ignoring the latter.

If we see the hostile actions of the peasants in Oaxaca and Brazil in opposition to the metric system in out of context, they may look irrational, marginal, and inexplicable. The Chatino Indians from Juquila and the Quebra-Quilo rebels were described by some of their contemporaries as uncivilized, drunken, maddened, etcetera; today many historians and anthropologists have ignored or diminished the importance of weights and measures in the practical and symbolic life of these people. Both nineteenth-century observers and present day social scientists failed to see the protection of traditional means of measurement as a moral and rational action.

When the principles of the moral economy are not observed people usually react in consequence, sometimes violently. Crowds are not blind and meaninglessly destructive, their actions are guided by specific principles. The destruction of measures and the opposition to the introduction of new units of measurement are examples of this.

Iconoclasts—breakers or destroyers of images of religious veneration—have been fairly well studied. But *mesuroclasts*—breakers or destroyers of measures—have not received proper attention. As I have tried to show here, the destruction of weights and measures (especially of metric ones) is not something new. And the destruction of kilogram weights by nineteenth-century peasants in Latin America is as meaningful as the destruction of a statue of the Virgin Mary by protestant Germans in the sixteenth century.

CONCLUSIONS

A World Too Small for Two Systems

> Now after World War II, new interest in the metric system has arisen and we think it will be accepted universally. Our world is too small for two systems.[1]
>
> *J. T. Johnson*

The decimal metric system has become so close to us that we constantly lose sight of the astonishing fact that this very same measurement system employed to calibrate pipettes in Canberra, to indicate the scale of a map of Siberia, and to weigh the chemical elements in a laboratory in Cairo, is used by milkmen in Vienna, butchers in Ottawa, and leather shoemakers in Guanajuato. This amazing coordination was literally unimaginable at the beginning of the modern era. The article on "Measure" in Diderot's *Encyclopedia* reads "It is a well-known fact that people will never agree to use the same weights and the same measures."[2] Due to a beautiful irony in history, the intellectual heirs of the encyclopedists proved their mentors wrong and created the first universal weights and measurement system: the decimal metric system.

How was this universal language possible?

[1] *Morning World-Herald* (Omaha), March 11, 1946.

[2] "Mesure," in *Encyclopédie, ou Dictionnaire raisonné des sciences, des arts et des métiers, par une société des gens de letters* (Paris: De l'imprimerie de Le Breton, imprimeur ordinaire du Roy, 1765), 10: 424.

The "Universal Inter-Dependence of Nations"

In their vivid description of the effects of capitalism on history, portrayed in the *Communist Manifesto,* Karl Marx and Friedrich Engels underlined the global character of capital and its relentless consequences for social life. Capital, as Marx and Engels insisted, is a force that undermined local economies and social relations; it transformed not just Europe, but China, India, the Americas—the entire world. Under capitalism local customs became substituted for cosmopolitan customs:

> In place of the old local and national seclusion and self-sufficiency, we have intercourse in every direction, universal inter-dependence of nations. And as in material, so also in intellectual production. The intellectual creations of individual nations become common property. National one-sidedness and narrow-mindedness become more and more impossible and from numerous national and local literatures, there arises a world literature.[3]

The material side of this "universal inter-dependence of nations" is well known: global circulation of commodities, international division of labor, expansion of capital throughout the planet. This material intercourse created—and required—intellectual means; languages that would allow the existence of this global interaction. A universal world cannot rely on the narrow-mindedness of localities and nations for its reproduction. Capital demanded universal languages that facilitate the communication and coordination among different groups, classes, nations, and regions that in the span of a few decades in the nineteenth century became extremely close to each other.

[3] Karl Marx and Friedrich Engels, *The Communist Manifesto* (London: Penguin, 2002) 223-224.

The metric system was one of these universal languages. Its universality was founded on exactness, abstraction, quantification, and standardization. And it was no accident that the first century fully ruled by capital—the nineteenth century—was the century when the metric system started and consolidated its planetary expansion.

Today it is difficult to conceive a world without standardization in weights and measures. But the eighteenth-century world differed greatly from ours in this respect. Three hundred years ago the world lived great metrological fragmentation. Explorers found different measures in every region—and sometimes in every town. Today, one person can travel from one continent to another and always use the decimal metric system. The metric system bolstered "the universal inter-dependence of nations," and has become itself a symbol of how the "intellectual creations of individual nations become common property."

But the metric system spread throughout the world one nation at a time. National-states were the effective force that imposed the metric system, although it was capitalism that created some of the basic conditions that made the unification of weights and measures desirable, and possible.

Also in the *Communist Manifesto* Marx and Engels explained how national-states and capitalism were related:

> The bourgeoisie keeps more and more doing away with the scattered state of the population, of the means of production, and of property. It has agglomerated population, centralised the means of production, and has concentrated property in a few hands. The necessary consequence of this was political centralisation. Independent, or but loosely connected provinces, with separate interests, laws, governments, and systems of taxation,

> became lumped together into one nation, with one government, one code of laws, one national class-interest, one frontier, and one customs-tariff.[4]

…and one system of weights and measures, I may add.

It is debatable, of course, how accurate the ideas by Marx and Engels about the causes of political centralization were. But it is easier to agree on how important the processes of unification produced by the states were. And, in the end, it is difficult to deny that unification of government, laws, customs-tariff, weights and measures, and the like was favorable for capital expansion (no matter what actually motivated such centralization).

In the opinion of Eric Hobsbawm, the third quarter of the nineteenth century was the first time when the world was actually "unified." The telegraph, the steamship and the railway linked the most remote parts of the world. Goods and men moved massively from one corner of the globe to another. Capital transformed the material and spiritual milieu of humanity.[5]

It was an era marked by the colossal development of the world-economy, an era of industry and capitalism, "of the social order it represented, of the ideas and beliefs which seemed to legitimate and ratify it: reason, science, progress and liberalism."[6] It is telling that these four ideas and beliefs were frequently alluded to justify and explain the introduction of the metric system in non-European territories. And this period (1850-

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[4] Marx and Engels, *Communist Manifesto,* 224.

[5] Eric Hobsbawm, *The Age of Capital, 1848-1875* (New York: Charles Scribner's Sons, 1975), 13-18, 64-87.

[6] Hobsbawm, *The Age of Capital*, 15.

1875) was actually critical for the metric system, and for many other international initiatives (like the creation of international standard time, the International Telegraph Union, the Universal Postal Union, and the International Meteorological Organization). And it was precisely in 1875 when the Convention of the Meter took place in Paris, with seventeen nations signing the treaty of the meter. Looking at it in a broader perspective, the metric system was part of a series of projects that helped to build international and interlinguistic mechanisms of standardization and coordination in a context when the world was becoming increasingly unified.

Sarton's Question

But we should be careful with this narrative and with this broad generalization that equates global metrication with global capitalism. We should get back to George Sarton's question: "Why did the most industrial and mercantile nation in Europe reject the metric system, while its use would have caused great economies in time and money? Suppose the situation had been reversed, how tempting it would have been to explain the creation of the metric system as a necessary result of the superior mercantilism of England."[7] We need to account for other factors to explain the worldwide success of the metric system. Ultimately capitalism can only explain a part of this historical process; other important forces were in place as well—in the end it was Lenin and the Bolsheviks

[7] George Sarton, *The Study of the History of Mathematics* (Cambridge: Harvard University Press, 1936), 15.

who introduced the metric system in Russia and the rest of the Soviet republics, something that we cannot account for with the "capitalist hypothesis."

As I demonstrated in chapter one there are several macro-historical factors that should be considered in order to understand global metrication: geographical vicinity, national unifications, massive socio-political change (including revolutions), colonization, and independence from colonial rule. Colonization alone, for instance, accounts for the introduction of the metric system in around twenty-five percent of currently existing non-European countries.

Also, as I stressed in chapter two, the implementation of the metric system became handy for nation-states all over the world as an instrument to enhance administrative control and to gain leverage to fulfill some essential state functions: improving the extraction of revenue, making the population and economic resources "legible," monopolizing symbolic capital, undermining the influence of local authorities, consolidating internal markets, and introducing homogenous national institutions and practices. Furthermore, states were the institutions that provided two essential elements for any effective metrication campaign: policing the use of metric units in commercial and civil contracts, and providing populations with the intellectual and material means to learn the metric language (i.e. standards, instruments, teaching manuals, etcetera).

Finally the role the intelligentsia (scientists, engineers, educators, university professors, and men of knowledge in general) was crucial in this process as they fulfilled three vital functions: 1) through their communication circles they propagated information about the metric system and its advantages around the globe; 2) they provided states with the necessary expertise to articulate and materialize the adoption, management, and teaching of the metric system; 3) they articulated the legitimation of the metric system by entangling it with the values of science, civilization, and universality.

These conditions, institutions and groups, explain why and how the metric system became an almost universal language of measurement—but we still have to explain that *almost*.

Why Is There no Metric System in the United States?

To answer this question it is important to understand the historical and social specificity of actors and circumstances (national and international) directly involved in the use, establishment, and enforcement of weights and measures in the United States. That is to say that any aspect of the so called "American exceptionalism" should not be solved by resorting to ahistorical, general, vague, or abstract characteristics of the "American people" or the "American character."

Clichés are remarkably persistent. During the years I was conducting the research for this dissertation I had the opportunity to talk with many intelligent and educated people about my work. More often than not, when people heard that I was trying to find out why there is no metric system in America, I immediately received all sorts of essentialist comments. A professor of International Affairs at Columbia University, for example, told me "Because we Americans want to be different." A graduate student at the University of Chicago asked me "So, are you studying stubbornness?" A novelist in Mexico City claimed "Well, that's because *gringos* are very square, isn't it?" This type of reasoning even translates sometimes into more formal explanations about the United States resistance to metrication. For instance, people have tried to portray Canada, New Zealand, South Africa, the United Kingdom, and the United States as natural barriers to the metric system because they are societies based on democracy and private property (disregarding the fact that in all those countries, except America, the metric system was introduced decades ago) in contrast to countries with authoritarian, top-down forms of government.[8]

Rather than opting for these quasi-sociological mystifications, we should invoke Werner Sombart and the way in which he looked into the enigma of why there is no socialism in the United States. It would have been very easy—and popular—to solve that question by saying that there is no socialism in the United States because Americans love freedom and are individualistic, for example. But Sombart evaded that. Instead he focused on the workers and their living conditions (like the style of public life in America), their political position (like the monopoly of two major parties, the failure of third parties, the place of workers in the state), their economic situation (income, cost of living), and so forth.[9] Likewise, Andrei Makovits, while tackling the question of why soccer was highly popular around the world except in the United States, avoided answers like "soccer is boring because there are very few goals," or "baseball is more beautiful and elegant than soccer." He rather studied the formation of the American sports arena,

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[8] See on this Andro Linklater, *Measuring America* (New York: Walker and Company, 2002), 248-249.

[9] Werner Sombart, *Why is there no Socialism in the United States?* (White Plains, N.Y.: M. E. Sharpe, 1976).

how other sports crowded professional sports, etcetera.[10] They studied the historical specificity of the phenomenon at hand, instead of deducing answers from conventional national images.

The metric question in America, similarly, should not be solved through the issue of the intrinsic virtues of the metric system or through the “character” or “essence” of Americans. The metric system has not been adopted in the United States not because it is better or worse than the English customary system, nor because Americans are “pragmatic,” “democratic,” or “conservative.” This question demands a sociological and historical explanation.

Following what was presented in this dissertation, it is possible to point out to the key factors that explain the failure of the United States to adopt the metric system as its exclusive system of measurement:

- *A weak state*—i.e. a federalized, and highly fragmented state. Since its beginnings in revolutionary France, metrication has been an achievement (and symbol) of political centralization. In every country the meter has subjugated hundreds of local and regional metrological units, legislations, and practices. But the American state has not been able to concentrate the administration and regulation of weights and measures in the hands of the federal government, and the ratio of power of the states and local government vis-a-vis Washington is particularly high and they have been able to maintain a considerable degree of metrological autonomy. This, in turn, has halted the plans for a federal, mandatory metric policy.

[10] Andrei S. Markovits and Steven L. Hellerman, *Offside: Soccer and American Exceptionalism* (Princeton: Princeton University Press, 2001).

- *World economic predominance*. The size and power of American economy has granted the United States the ability to impose its conditions in international trade agreements—including defining metrological standards. This has allowed the United States to enforce the use of English customary measures as *de facto* standards in several areas of production and exchange. So, for example, despite growing economic integration and the subsequent necessity for international coordination (e.g. the European Union has pushed England and Ireland to advance their processes of metrication) Mexico and Canada did not have the leverage to demand the exclusive use of the metric system in all the NAFTA territory.
- *Strong, organized opposition*. A key economic sector in the country, the manufacturers, was against the transition to metric measures throughout the entire twentieth century. Their tenacious opposition prevented the pro-metric front from presenting "unanimous" support for the metric system before Congress. Furthermore, mechanical engineers in America—an important and well-organized group among experts—mounted a solid case in mass media, scientific publications, and political debates against the convenience of adopting the metric system. This antagonism was sufficient to make the compulsory introduction of the metric a polemic issue. Probably a solid presentation by pro-metric scientists, educators, large scale merchants, and industrialists, without the opposition by manufacturers and mechanical engineers, would have been enough to secure favorable metric legislation—but this *probably* should be stressed, as this was not the only condition that prevented American metrication.
- *People at large were rather indifferent, if not hostile, to metrication*. Despite multiple efforts by schools, government agencies and pro-metric associations, the knowledge of what the metric system is and how it works among the American population has been rather limited and inadequate. Ironically (and contravening all the predictions by the advocates of metrication) the few times that the problem has been analyzed studies

show that resistance to metrication grows as familiarity with the metric system increases.[11] And an entrenched trait in American political culture, the "aversion to compulsion," has greatly undermined the chances of the metric system becoming the exclusive and mandatory system of measurement in the country.

- Finally, *timing*. At the end of the eighteenth and the first decades of the nineteenth century, America had good chances of adopting a system of measurement different from the English customary one, but the metric system—which could have been a perfect answer for the problems that Americans wanted to solve at the time—was not yet finished (as happened with Thomas Jefferson's report in the 1780s) or was not in actual use in any other country (as occurred during John Quincy Adams' report in the 1810s). American reformers were in the right place at the wrong time. In hindsight, the key year in American's metrication history was 1866, after the Civil War; at that moment the metric system was already a recognizable international force; the Reconstruction era was a propitious moment for metrication as plans of national unification, expansion of the administrative functions of the state and economic modernization were on the rise; but failure to procure definitive actions at that moment generated—unintentionally—the development of numerous industrial and technical processes in the country without the use of metric units, something that made any future change to the metric system more expensive and burdensome. When it was clear that the metric system was the unquestioned global language of weights and measures, the United States was already "locked-in" with the customary system.

[11] George H. Gallup, *The Gallup Poll: Public Opinion, 1972-1977* (Wilmington, Del.: Scholarly Resources, 1978), 967-968.

Legacies of the French Revolution:

The Metric Triumph—And Everyone Else's Failure

How can we explain that the success of the metric system in contrast to the failure of other decimal systems invented simultaneously during the French revolution, in particular decimal systems of time reckoning? And what can we learn from the failure of other international convention analogous in their intent and spirit to the metric system, like the idea of a universal currency?

The case of international currency can serve to illuminate an important aspect of the metric system's global triumph. Since no other "modern" or "scientific" plan was able to seriously challenge the metric system, people in different countries and from different professions interested in a radical metrological reform were galvanized around a single project, instead of being divided in discussions about the virtues and defects of every single hypothetical plan. For better or worse, the metric was what they had, and this lack of options granted them greater solidarity. On the contrary, when the suggestive but controversial idea of international currency was discussed, experts and diplomats were divided among the many possible ways to materialize that idea, and that weakened their position significantly.

Decimal time was a very good idea that did not catch on either. As I showed in chapter one, its origin was full of promise, but its history is one of repeated rejection. One of the ironies—or tragedies—in its history was that the more serious attempts to institute decimal time were coupled with projects that enjoyed extraordinary success. In the 1790s, decimal time was the twin reform of the metric system, but only the meter turned out to be a universal unit of measurement. Decimal currencies, other invention parallel to decimal time, became a ubiquitous feature in modern societies. In the 1880s, French scientists tried fruitlessly to link decimal time with the establishment of the system of time zones, one of today's central pieces for temporal coordination. Decimal time is a foiled project while its fellow proposals are now universally used. How can we account for these divergent destinies?

Decimal time did not fail due to its "overemphasis on the totality of the obliteration of the traditional system of units of time and time-reckoning."[12] The metric system also broke radically with the past but was accepted anyway. All the more, the metric system might have been even more radical, since it did not carry any of the previous units of measure used in France prior to the revolution; the Republican calendar kept using the 365-day year and the day itself, and in that regard it was not completely new. Dealing with novelty and rupturing with the past do not appear to be among the main reasons why decimal time failed.

It also has been said that decimal time did not stick, while the meter did, because the "calendrical reform entailed France's international isolation, whereas the metric reform did not."[13] This assertion makes sense for today's world, but not for Europe in the 1790s. When it was created the metric system represented international isolation for France in the realm of weights and measures (essential for all commercial transactions) as much as the republican calendar did for temporal orientation. When the meter, liter, and

[12] Zerubavel, "The French Republican Calendar," 874-875.

[13] Zerubavel, "The French Republican Calendar," 876.

kilogram were established *nobody* in the world—except for their inventors—knew what they were, what magnitudes they represented, what their names meant, and how their subdivisions related to each other. Despite the problems caused by the lack of standardization, there were many similarities among the units of length, volume, and weight in Western Europe prior to the revolution, they usually represented different magnitudes, but they had common names and the same logic for grouping and divisions. The metric measures broke that shared understanding, *within* and *outside* France, the same as decimal time and the new calendar—but the metric system prevailed nevertheless. International isolation does not account for these differences either.

The key to understanding the metric success and the chronological and calendrical failure is that the metric system wanted to substitute a *multitude of systems* of measurement; while the republican calendar aimed to replace *one system* of time reckoning. In other words, the metric system confronted a disarray of local and uncoordinated measures, while decimal time clashed against a well-established system. In this regard, it is not surprising that a reform of weights and measures was a popular demand and the metric system helped to solve a pressing need felt for different social groups. And the open indifference faced by decimal time can be explained by the fact that only a tiny group of savants and politicians perceived the traditional time systems as a problem that needed to be fixed.

Another reason is that metrication was sponsored by scientific societies and large scale merchants, and financed and implemented by nation-states all over the world. Besides, the set of institutions and political authorities that allowed the existence of pre-metric units of measurement in Europe (namely feudal rights and lords) were demolished by the modern states. And something similar happened with decimal currencies, the diffusion of which was in concert with "the spread of national fiduciary money produced under government monopoly."[14] Decimal money replaced duodecimal and vigesimal monetary systems because it counted with permanent support from national states during the last two centuries. Decimal time in contrast has been an *institutional orphan* ever since the French authorities decided to drop it out; not even scientific societies (usually the more enthusiastic groups in promoting decimal systems) could present a common front to push in favor of chronological decimalization.

The difficulties—and ultimate failure—to establish decimal time can teach us a final lesson. The use of decimals for counting, calculating, and measuring is not a given. The predominance of decimals is the product of historical contingencies and negotiations. If certain circumstances had been present, time reckoning would be fully decimalized; and the scenario of not having a decimal system of measurement was a possibility as well. If the groups and institutions that supported the metric system had been less influential, it could have faced the same fate as decimal time. But this also means that the future is open, and decimal time may someday find more favorable conditions to flourish.

Systems of orientation, technical standards, and scientific languages are the product of unpredictable contingencies. The metric system (or the Gregorian calendar, or Hindu-Arabic numerals for that matter) was not preordained to become a staple of human

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[14] Adrian Tschoegl, "The International Diffusion of an Innovation: The Spread of Decimal Currency," *Journal of Socio-Economics* 39 (2010): 101.

thinking and conceptualization, as it is today. The metric system could have become a footnote in history—as happened to the republican calendar, decimal time, and the soviet five-day week, for example. Under different circumstances, and with different balances of power between different social groups, another system of measurement could have become the prevalent international system of weights and measures. Also within the realm of possibilities latent in the last two centuries of world history was a scenario where every country could have maintained a distinctive or "national" measurement system (as happened with money, where national-territorial currencies emphatically defeated the prospects of a universal currency). The future was open in the eighteenth century, when the history of the metric started; and it is still open today.

Metric and other Global Diffusions

The global expansion of the metric system is a phenomenon of extraordinary proportions. Since we live today in a metric world it is difficult for us to grasp what a colossal—and improvable—enterprise it was. To better understand it, we may need to contrast global metrication with some other languages and institutions similar to the metric system that also operate at a planetary scale, like Hindu-Arabic numerals and International Time Zones. Also useful is to compare the accomplishments of the metric system with projects of a similar kind that turned into failures, like the plans to decimalize time reckoning.

For Hindu-Arabic numerals it took more than one thousand years (from around 500 A.D. to the end of the sixteenth century) to be known in Asia, Africa, Europe, and the Americas; and even at the beginning of the nineteenth century it could not be taken for granted that people of all walks of life would know who to use them (symptomatic of this is that introductory pages in some manuals of weights and measures in the early nineteenth century usually contained a brief explanation of what the names, symbols, and meaning of those numerals were). Their travel from India to Islamic Asia and Africa took around three centuries (Al-Khwarizmi's work on calculation with Hindu-Arabic numerals appeared around 825), and started to penetrate Europe around the end of the tenth century (with Fibonacci's *Liber Abaci,* a work crucial for their popularization, was printed in 1202), but they were not widely known there until the fifteenth century.[15]

Two main difficulties made this diffusion process very slow (in contrast to the 200 years that the metric system needed to go from Paris to Quito and Sydney and everything in between). First, Hindu-Arabic numerals demanded to be learned by a critical mass of people in order to be socially operational; this was the barrier of a language lacking enough speakers at a time when communication and transportation were rather longwinded. Second, Hindu-Arabic numerals clashed with other numeral systems that were preferred—and protected—by authorities in several places. In fourteenth-century Florence, for example, money changers were obliged to use Roman numerals and forbidden to employ Hindu-Arabic figures.[16] In Russia, Cyrillic numerals were favored

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[15] On the history of Hindu-Arabic numerals see Karl Menninger, *Number Words and Number Symbols* (Cambridge: MIT Press, 1969), 389-445.

[16] D. J. Struik, "The Prohibition of the Use of Arabic Numerals in Florence," *Archives Internationales d'Histoire des Sciences* 21 (1968): 291-294; D. J. Struik, *A Concise History of Mathematics* (New York: Dover Publications, 1987), 81.

over their Asian counterparts as long as the eighteenth century, when Peter the Great ordered the use of the Hindu-Arabic digits.

On the other hand, the spread of Hindu-Arabic numerals had the advantage of not needing much of a material or technological basis to be employed; no especial instruments are indispensable to count and calculate using the symbols *0, 1, 2, 3, 4, 5, 6, 7, 9*—if something ink and paper are all it is required. In the long run, the triumph of Hindu-Arabic numerals set the indispensable conditions for the future attainment of the *decimal* metric system; had a non-decimal numeral system conquered the world instead, the need to revolutionize the arithmetic base of customary measurement systems would not be so pressing.

A more recent example suitable for comparison with the expansion of the metric system is the international Time Zones system. The Meridian Conference that brought about this arrangement was held in Washington in 1884—in part thanks to the lobbying efforts made by the American Metrological Association, which was actually one of the first and most energetic pro-metric organizations in American history. The final agreement that set in place our familiar partitioning of the world into twenty-four different hour zones with Greenwich serving as the prime meridian came after fierce resistance from the French delegation in that conference. The main obstacle was not a cognitive barrier—like the one halting the spread of Hindu-Arabic numerals—because setting international time zones did not required for clock users to get familiar with a new and fancy time reckoning technique; neither they needed to change how their time pieces work or to replace their old watches with new models. For lay people the international standard time only meant synchronizing their watches with a public clock—mainly the one in train stations. What was difficult for this institution to be accepted was surpassing political disagreements between rival nations and subduing the spirit of autonomy of some jealous cities that did not want to set their time according to the British observatory.[17] Nevertheless, and despite this opposition, in less than fifty year international time zones prevailed globally—and became one of the brightest instances of effective internationalism. Only very recently challenges have come about to alter this chronological order, with the creation of "Mecca Time," based on the idea—advanced by a group of Muslim clerics in 2008—that the holy city of Islam in Saudi Arabia is the center of the world and as such it should replace Greenwich as the prime meridian; the world largest clock, sited atop the Royal Mecca Clock Tower, started ticking in August 2010 to mark this time.[18] How much penetration this new plan will have among regular people is still to be seen, but it is a reminder of the negotiated and contingent character of all international standards.

For both historical and practical reasons, the metric system was able to gain world acceptance much quicker than Hindu-Arabic numerals, but it was slower than international time zones. As the time reform, the metric system had the advantage of being created in a moment when global interconnectivity grew very rapidly; it was also helped by a vision of internationalism that pushed forward many world-wide initiatives

[17] Eviatar Zerubavel, "The Standardization of Time: A Sociological Perspective," *American Journal of Sociology* 88 (1982): 1-23.

[18] Magdi Abdelhadi, "Muslim Call to Adopt Mecca Time," BBC, April 21, 2008; "Saudis hoping giant clock will set 'Mecca Time' " AFP, August 10, 2010.

(and the metric system, in return, enhanced greatly the idea of internationalism by being a living proof of its benefits).[19] However, the metric reform shared the inherent limitations that stop the progress of both Hindu-Arabic numerals and international time zones.

As Hindu-Arabic numerals, the metric system represented a cognitive barrier for the immense majority of its targeted users—which at the dawn of the nineteenth century included all humankind except for a few thousand individuals, the majority of them scientists and French public servants. Created afresh—negating history in all its specifications—the metric system was novel for users in its dimensions, names, and arithmetic; but to actually work as a universal language for quantities, as its creators envisioned it, the metric system needed to be employed not only by an enlightened minority, but by peddlers, housewives, butchers, shoemakers, and so forth. Again, a language—even a technical and scientific language—requires speakers, and the metric system had none; almost everything in the front of metric literacy had to be done (the importance to have speakers makes the different strategies of appropriation of the metric system crucial to explain its success; the problem of appropriation is then essential for any research on metrication that tries to understand how people started talking—or babbling—in metric language and how they eventually fully make it their own). And as the setting of the Greenwich meridian as the benchmark for international time zones, the metric system had to fight against all kinds of national bias and needed to answer

[19] Martin H. Greyer, "One Language for the World: The Metric System, International Coinage, Gold Standard, and the Rise of Internationalism, 1850-1900," in *The Mechanics of Internationalism,* ed. Martin Geyer and Johannes Paulmann (New York: Oxford University Press, 2001), 55-92.

questions like "Why should *we* (American, Britons, Chinese…) have to accept a *French* system in favor of our customary weights and measures?"

To these complications we should add another that neither Hindu-Arabic numerals nor universal chronological coordination had to endure, but one that heavily curbed the pace of the metric system. *Metrication demands a massive renovation of tools and machinery*—accompanied with the parallel job of destroying the instruments and standards adjusted and calibrated to the old units of measurement which had to be burned, broken, melted, or buried into the sea to avoid confusions and commercial wrongdoings. When compulsory metric laws enter into effect and customary units became obsolete by means of legislation (usually after a window of tolerance that lasts between one to ten years, depending of the country) the possession and employment of millions of measuring instruments became unlawful and their owners subject to fines or even prison. Calipers, gauge blocks, yardsticks, rods, measuring chains, surveyor's wheels, tape measures, rulers, odometers, bushels, barrels, pints, measuring coups, pipettes, water meters, balances, weights, steelyards, scales, and a long list of other measuring, gauging, and weighing appliances were either adapted to metric units or confiscated and burn into ashes. Also, technical manuals, blueprints, cadastral maps, and the like had to be translated into the metric idiom. Brand new metric devices and technical literature had to be acquired or produced. When countries decided to switch to the metric system it is the best of times for instrument makers; it is the worst of times for stores and workshops.

It is difficult to offer an approximation of how many metric instruments have been built due the sudden demand produced by compulsory metrication around the world. Just to give a sense of the dimensions of this forced retooling, an estimation made in Mexico in 1886 of the number of brand new metric instruments that would be necessary to equip the 3422 testing offices in districts and municipalities indicated that about two hundred thousand metric tools had to be built or bought to provide those weights and measures offices with barely the *essential* equipment (wooden meter sticks, tinplate liters, brass kilogram weights, etc.).[20] This fifth of a million devices would be only good to equip the inspectors and did not include all the instruments used in commerce, agriculture, and domestic life that should be tested and calibrated annually against those official tools. What's more, they needed to make sure that these secondary standards were actually faithful and tested with the federal standards held by the federal government.

An enormous operation of distribution of knowledge—to guaranty that people can have command of the new measurement concepts—had to be accompanied with the industrial production of physical standards in which the system was materialized. Both of these processes are necessary for the appropriation of the metric system to actually happen. If someone has a meterstick and a kilogram scale, but possess no knowledge of the metric magnitudes, names, and logic of grouping and subdivisions, those instruments are useless. And the same goes if a person understands the system conceptually, but does

[20] "Cálculo del costo que tiene una serie de los pesos y medidas del nuevo sistema métrico decimal," AGN, Pesas y medidas, box 1, file 22. The total cost of these instruments was calculated in 131,382 Mexican pesos.

not have the measuring gadgets. Both of these circumstances have occurred repeatedly in all corners of the world during the last two centuries and have represented steep difficulties for states, societies, and individuals. Considering these obstacles, that the transition to the metric system has been successfully accomplished all around the world is one the great achievements of humanity.

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CU - Rare Book & Manuscript Library, Columbia University

HN - Hemeroteca Nacional de México

HSSL - Humanities and Social Sciences Library; New York Public Library

NYHS - New York Historical Society

SIBL - Science, Industry, and Business Library; New York Public Library

SMGE - Archivo Histórico Ignacio Manuel Altamirano, Sociedad Mexicana de Geografía y Estadística

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Appendix A

Adoption of the Decimal Metric System of Weights and Measures by Country

This table shows the 196 existing countries according to the grid of national states in 2010 and their respective year of official adoption of the decimal metric system as the compulsory and exclusive system of measurement.

The countries marked with an **N/M** at the end of the table are non-metric countries.

When countries are followed by a **C** indicates that the metric system was introduced when that country was a colony; if it is followed by an **S** means that the metric system was introduced when that country was part of a larger political entity from which it seceded. Both of these cases are considered non-voluntary adoptions.

The column **Opt.** indicates, when appropriate, the year when the use of the metric system became optional in that country.

The column **Vicinity** indicates—for the voluntarily adopters—the number of years before or after one of the country's neighbors adopted the metric system.

COUNTRY		ADOPT.	OPT.	VICINITY
France		1795		-21
Belgium		1816		0
Luxembourg		1816		0
Netherlands		1816		0
Algeria	C	1840		
Senegal	C	1840		
Spain		1849		54
Portugal		1852		3
Ukraine	S	1922		
Libya	C	1923		
Indonesia	C	1923		
Afghanistan		1923		1
Togo	C	1924		
Iran		1927		4
Iraq		1930		3
Syria	C	1934		

Monaco		1853		53
Colombia		1853		-9
Mexico		1857		-53
Venezuela		1857		4
Cuba	C	1858		
Italy		1861		66
Brazil		1862		0
Peru		1862		0
Uruguay		1862		0
Romania		1864		-5
Chile		1865	1848	3
Ecuador		1865		3
Dominican Republic		1867		14
Germany		1868		75
Bolivia		1868		3
Turkey		1869		5
Suriname	C	1871		
Croatia	S	1871		
Czech Republic	S	1871		
Liechtenstein	S	1871		
Montenegro	S	1871		
Slovakia	S	1871		
Slovenia	S	1871		
Austria		1871		3
Serbia		1873		2
Hungary		1874		4
Sweden		1874		6
Switzerland		1875	1868	4
Mauritius	C	1876		
Argentina		1877	1863	9
Seychelles	C	1878		
Bosnia and Herzegovina	S	1878	1910	
Costa Rica		1881		-12
Norway		1882	1875	8
Benin	C	1884		
Chad	C	1884		
Congo, Republic of the	C	1884	1960	
Côte d'Ivoire	C	1884		
Mauritania	C	1884		
Niger	C	1884		

Andorra		1934		85
Lebanon		1934		0
Israel		1947		13
Albania		1948		60
Korea, North		1948		30
Korea, South		1949		1
Egypt		1951	1873	3
Japan		1951		2
Bhutan		1951		-3
Taiwan	S	1952		
Jordan		1952		5
India		1954	1920	3
Sudan		1954		31
Timor-Leste	C	1957		
Macau	C	1957		
Greece		1957	1836	9
Madagascar		1957		43
Maldives		1959		5
Mali		1960		0
Burkina Faso		1960		0
Central African Rep		1960		6
Gabon		1960		1
Somalia		1960	1950	62
Cameroon		1961		1
Kuwait		1961		31
United Arab Emirates		1961		34
Eritrea	S	1962		
Ethiopia		1962		2
Nigeria		1962		1
Nepal		1963		9
Laos		1963		41
Saudi Arabia		1964		3
United Kingdom		1965	1864	58
Namibia	S	1967		
Ireland		1967	1897	2
South Africa		1967		62
Pakistan		1967		13
Tanzania		1967		0
Uganda		1967	1950	0
Kenya		1967	1953	0
Singapore		1968		45

El Salvador		1885		-10
Finland		1886		4
Macedonia	S	1888		
Bulgaria		1888		15
Sao Tome and Principe	C	1891		
Tunisia	C	1893		
Nicaragua		1893		8
Honduras		1895		2
Djibouti	C	1898		
Puerto Rico	C	1899		
Paraguay		1899		22
Equatorial Guinea	C	1900		
Iceland		1900		18
Guinea	C	1901	1959	
Guinea-Bissau	C	1905		
Angola	C	1905		
Cape Verde	C	1905		
Mozambique	C	1905		
Philippines	C	1906		
Denmark		1907		7
San Marino		1907		38
Congo, Democratic Rep.	C	1910		
Burundi	C	1910		
Rwanda	C	1910		
Malta	C	1910		
Belize	S	1910		
Guatemala		1910	1894	15
Vietnam	C	1911		
Thailand		1912		1
China		1913		-3
Comoros	C	1914		
Panama		1915		34
Mongolia		1916		3
Russia		1918	1899	2
Poland		1919		1
Haiti		1920		53
Cambodia	C	1922		
Morocco	C	1922		
Western Sahara	C	1922		
Kazakhstan	S	1922		

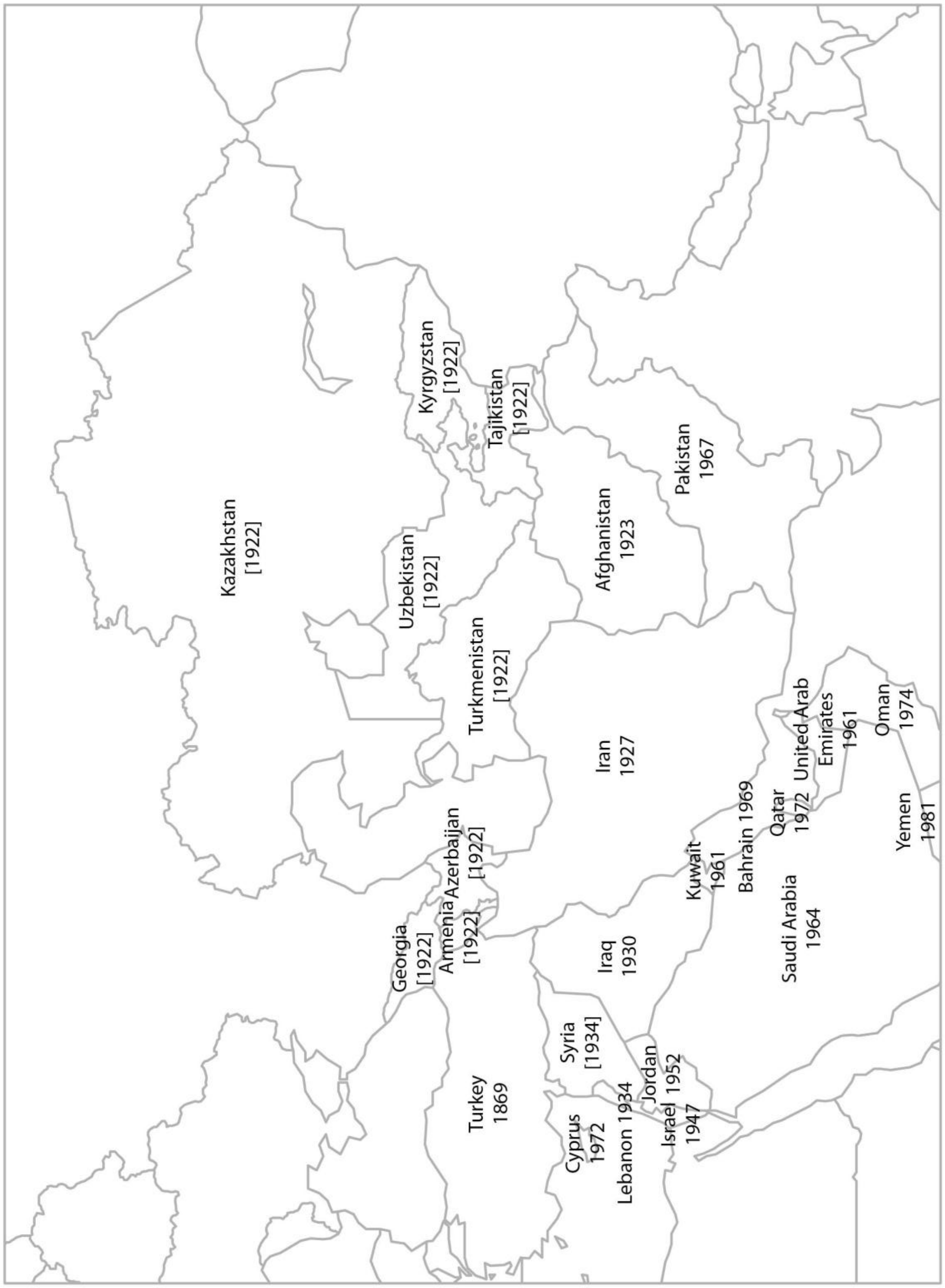
Australia	1969		0
New Zealand	1969	1925	0
Bahamas, The	1969		4
Zimbabwe	1969		0
Botswana	1969		0
Swaziland	1969		1
Bahrain	1969		3
Grenada	1969		0
Dominica	1969		112
Saint Vincent and the Grenadines	1969		0
Saint Kitts and Nevis	1969		-4
Canada	1970	1871	*
Sri Lanka	1970		11
Trinidad and Tobago	1970		1
Zambia	1970	1937	1
Lesotho	1970		3
Papua New Guinea	1970		0
Solomon Islands	1970		0
Malaysia	1971		3
Guyana	1971		100
Ghana	1972		12
Cyprus	1972		15
Fiji	1972		3
Qatar	1972		3
Jamaica	1973		53
Barbados	1973		3
Nauru	1973		-9
Oman	1974		7
Antigua and Barbuda	1974		5
Tonga	1975		3
Sierra Leone	1976		75
Malawi	1976		6
Gambia, The	1976		71
Tuvalu	1978		6
Yemen	1981		7
Bangladesh	1982		28
Kiribati	1984		6
Brunei	1985		14
Vanuatu	1988		16
Saint Lucia	2000		27

Kyrgyzstan	S	1922
Tajikistan	S	1922
Turkmenistan	S	1922
Uzbekistan	S	1922
Armenia	S	1922
Azerbaijan	S	1922
Belarus	S	1922
Estonia	S	1922
Georgia	S	1922
Latvia	S	1922
Lithuania	S	1922
Moldova	S	1922
Samoa	N/M	
Myanmar (Burma)	N/M	1920
Marshall Islands	N/M	1986
Micronesia, Federated States of	N/M	1986
Palau	N/M	1994
Liberia	N/M	
United States	N/M	1866

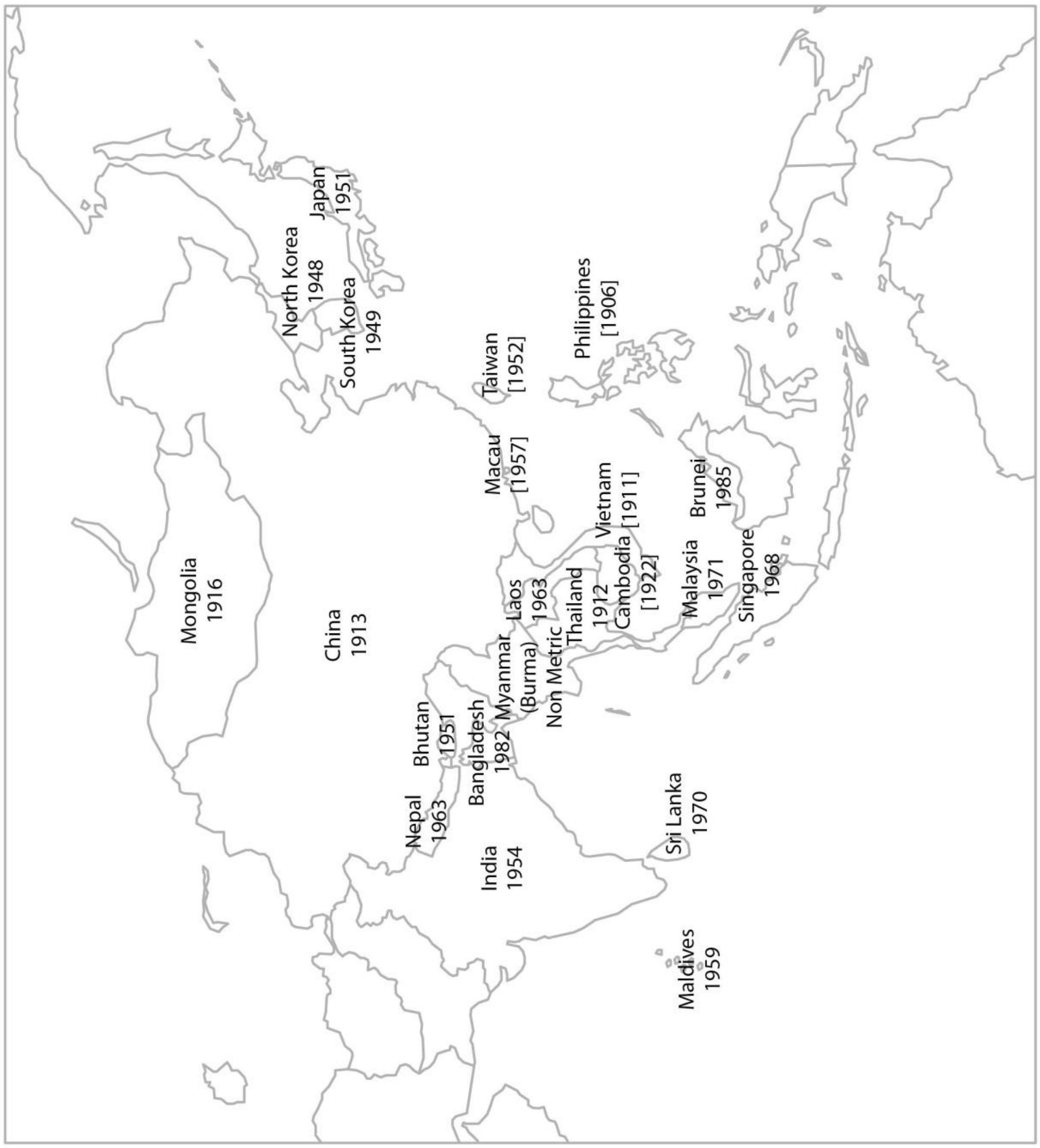
Appendix B

Maps Indicating the Year of Adoption of the Metric system by Country

B.1. Central Asia

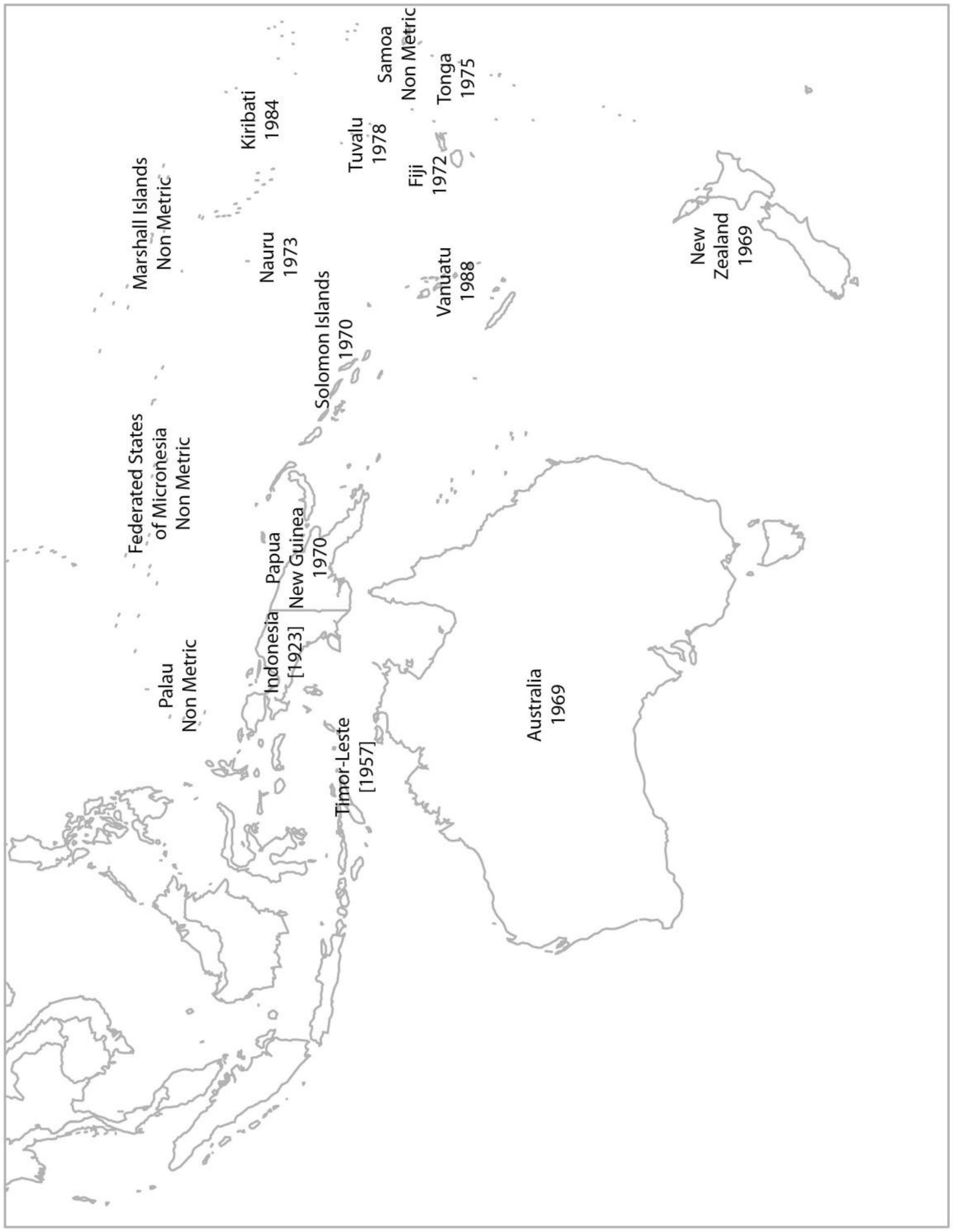


B.2. East Asia



Japan 1951
North Korea 1948
South Korea 1949
Philippines [1906]
Taiwan [1952]
Macau [1957]
Vietnam [1911]
Brunei 1985
Mongolia 1916
China 1913
Laos 1963
Thailand 1912
Cambodia [1922]
Malaysia 1971
Singapore 1968
Myanmar (Burma) Non Metric
Bhutan 1951
Bangladesh 1982
Nepal 1963
India 1954
Sri Lanka 1970
Maldives 1959

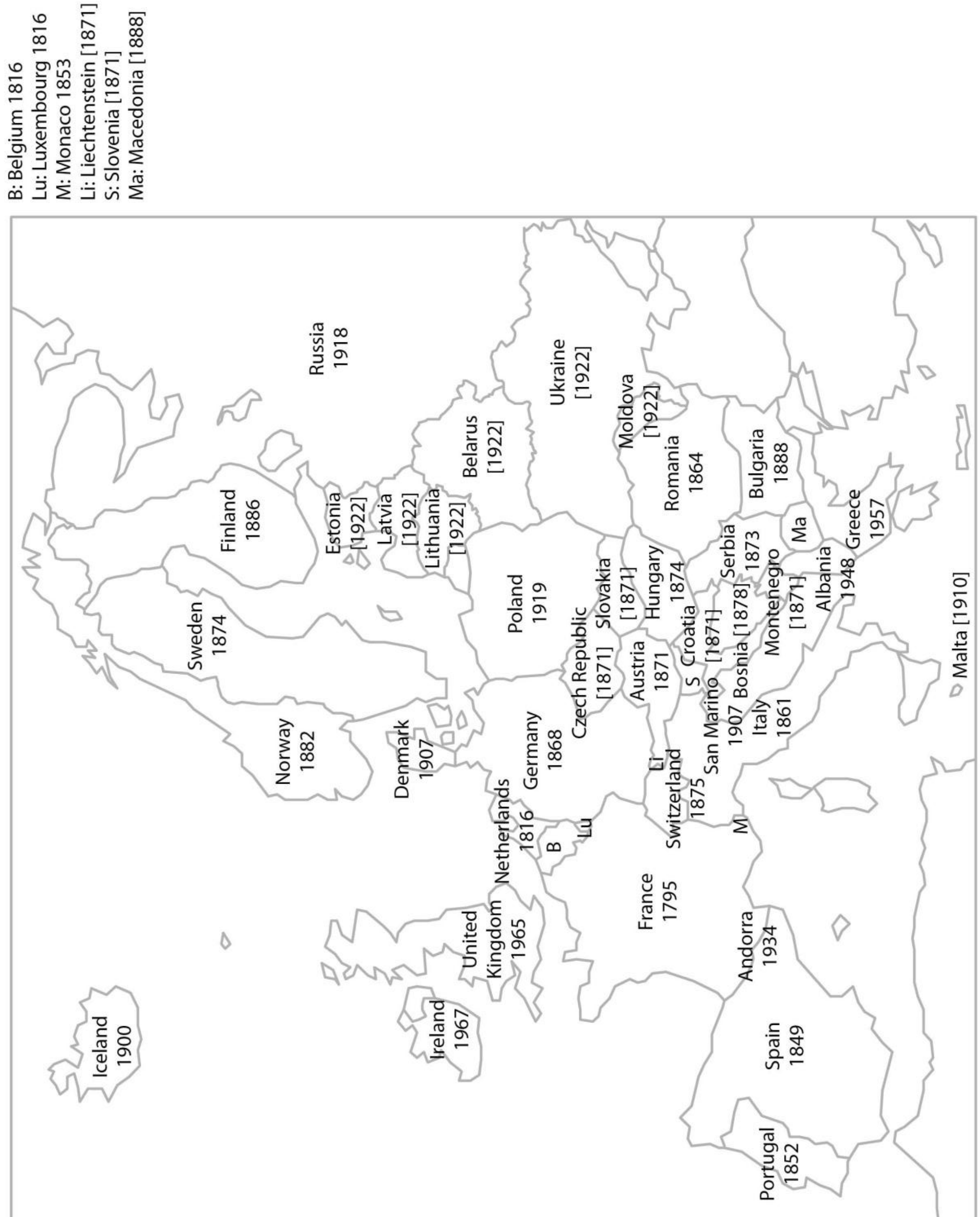
B.3. South East Asia and Oceania



B.4. Africa


Morocco [1922]
Tunisia [1893]
Western Sahara [1922]
Algeria [1840]
Libya [1923]
Egypt 1951
Cape Verde [1905]
Mauritania [1884]
Mali 1960
Niger [1884]
Chad [1884]
Sudan 1954
Eritrea [1962]
Senegal [1840]
Gambia 1976
Guinea Bissau [1905]
Guinea [1901]
Burkina Faso 1960
Djibouti [1898]
Sierra Leone 1976
Côte d'Ivoire [1884]
Ghana 1972
Benin [1884]
Nigeria 1962
Ethiopia 1962
Liberia Non Metric
Togo [1924]
Cameroon 1961
Central African Republic 1960
Somalia 1960
Equatorial Guinea [1900]
Sao Tome and Principe [1891]
Gabon 1960
Congo [1884]
Democratic Republic of the Congo [1910]
Uganda 1967
Kenya 1967
Rwanda [1910]
Burundi [1910]
Tanzania 1967
Seychelles [1878]
Comoros [1914]
Angola [1905]
Zambia 1970
Malawi 1976
Madagascar 1957
Mozambique [1905]
Mauritius [1876]
Namibia [1967]
Zimbabwe 1969
Botswana 1969
Swaziland 1969
Lesotho 1970
South Africa 1967

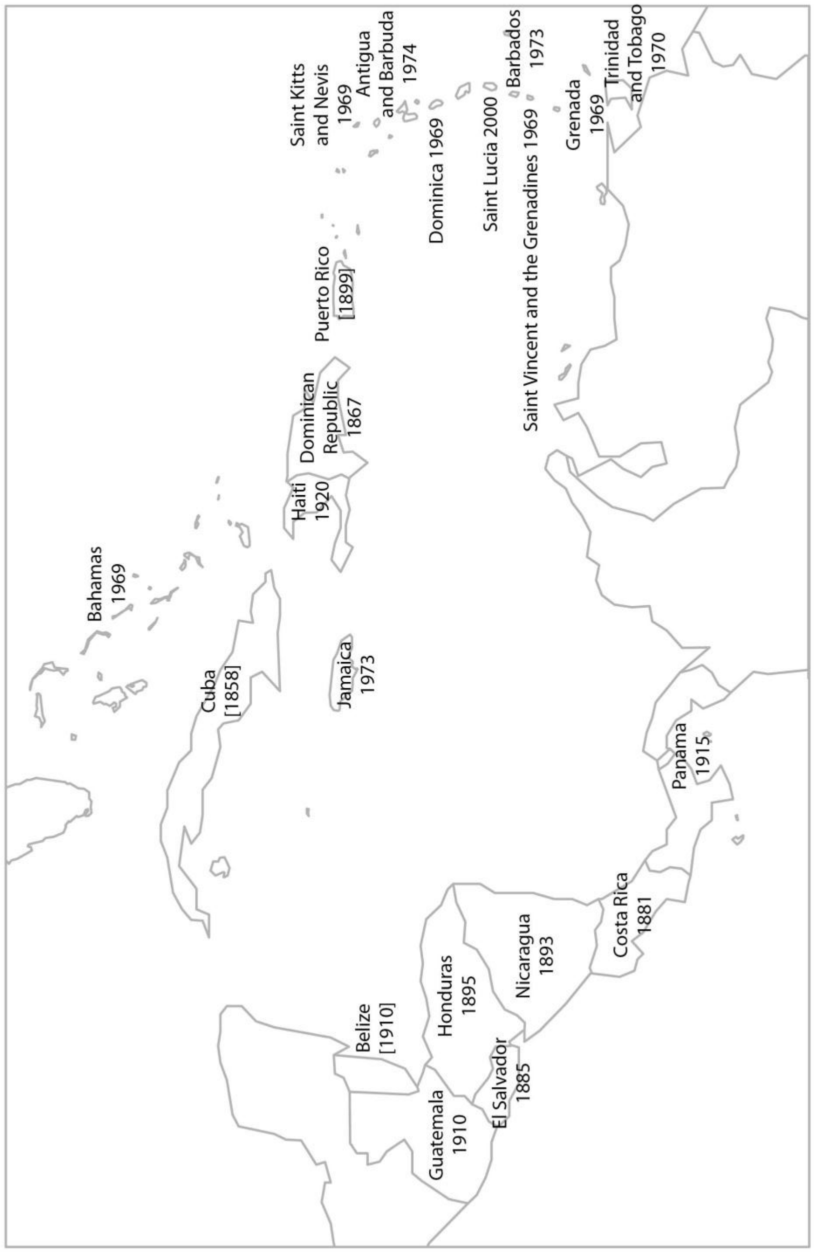
B.5. Europe



B: Belgium 1816
Lu: Luxembourg 1816
M: Monaco 1853
Li: Liechtenstein [1871]
S: Slovenia [1871]
Ma: Macedonia [1888]
Russia 1918
Ukraine [1922]
Belarus [1922]
Moldova [1922]
Romania 1864
Bulgaria 1888
Greece 1957
Ma
Finland 1886
Estonia [1922]
Latvia [1922]
Lithuania [1922]
Poland 1919
Slovakia [1871]
Hungary 1874
Serbia 1873
Montenegro [1871]
Albania 1948
Sweden 1874
Czech Republic [1871]
Austria 1871
Croatia [1871]
Bosnia [1878]
S
San Marino 1907
Italy 1861
Malta [1910]
Norway 1882
Denmark 1907
Germany 1868
Li
Switzerland 1875
M
Netherlands 1816
B
Lu
France 1795
United Kingdom 1965
Andorra 1934
Iceland 1900
Ireland 1967
Spain 1849
Portugal 1852

B.6. North America

B.7. Central America and the Caribbean



B.8. South America