

Ceremonies of Measurement

Rethinking the World History of Science*

Simon Schaffer

It is commonly imagined that practices of measurement can somehow escape the localized limitations of culture and society. Quantification's universalizing ambitions therefore play a major role in world histories and, above all, in the enterprises of scientific and commercial networks. It is claimed that measures of commodities and of data greatly help mobility and mastery. The techniques and results of such measurement processes are, so it seems, understood in the same way everywhere, as if they had no need of translation or of mediation, as if they could speak for themselves. No doubt all this explains why some historians have identified the advent of European modernity with the rise of the quantitative spirit, and, simultaneously, with the capacity of these Europeans to travel, loot, accumulate, and dominate beyond the limits of their own world and, in principle, everywhere.¹

* I would like to thank Frédérique Ait-Touati for her invaluable work, Dominique Pestre, Kapil Raj, and Nicholas Dew for their amicable advice, and the EHESS for inviting me to give the twenty-sixth annual Marc Bloch lecture (2014).

1. Alfred W. Crosby, *The Measure of Reality: The Quantification of Western Society (1250–1600)* (Cambridge: Cambridge University Press, 1997); H. Floris Cohen, *How Modern Science Came into the World: Four Civilizations, One 17th-Century Breakthrough* (Amsterdam: Amsterdam University Press, 2010).

Localization and Displacement

The man who in 1916 invented the word *mondialisation*, the Belgian internationalist visionary Paul Otlet, and his closest colleague, the Austrian philosopher and activist Otto Neurath, certainly believed that measurement practices would offer ways to build a new world order, in which boundaries between different systems of mediation would dissolve.² But measurement techniques always rely on complex mediations between instruments, tools, and practices. They are part of ritual systems that are at once communally shared and debatable, and it is neither easy nor self-evident to get them to move or work together. One must study the meanings that these measures had at the local level and find out about the ceremonies and practices that enabled them to act in many different and interconnected worlds. The concern in this article is to use these stories of mediations and rituals as ways of reflecting on the worldly extension of measurement practices and thus on that of the science of these practices, metrology.

The institutionalization of standards and discourses of standardization, not to mention classic tales from the history of the exact sciences, have often been taken as weapons of globalization, in the term's most aggressive sense. But it is also possible to consider the possibility of something more like a world history, a history that would study, in Roger Chartier's words, "the processes through which shared references, imposed models, texts, and goods that circulate on a planetary scale are appropriated to make sense in a particular time and place."³ It is no coincidence that in his commentary on history at the global scale, Chartier asked whether this history must "be a new form of the comparatism proposed by Marc Bloch in 1928."⁴ In this essay, likewise, it is a question of connecting Bloch's approaches to the rituals of measurement and conceptions of the universe with the possibilities of a world history of science.

Ceremonies of measurement have much to teach us about the importance of placing measurement within a world history of science, a history that would no longer assume an inevitable asymmetry between the quantitative reason of Europeans and the qualitative enterprises of other peoples. Consider for instance the measurements commonly carried out by Pacific mariners in the later eighteenth century, a moment when quantitative techniques for determining longitude at sea were celebrated as signs of triumphant Western modernity, and concern with the

2. Vincent Capdepuy, "Au prisme des mots. La mondialisation et l'argument philologique," *Cybergeo* 576 (2011): <http://cybergeo.revues.org/24903>; Nader Vossoughian, "The Language of the World Museum: Otto Neurath, Paul Otlet, Le Corbusier," in "L'œuvre de Paul Otlet," special issue, *Associations transnationales* 1, no. 2 (2003): 82–93.

3. Roger Chartier, "La conscience de la globalité (commentaire)," *Annales HSS* 56, no. 1, (2001): 119–23, here p. 123.

4. *Ibid.*, 119; see also Marc Bloch, "Toward a Comparative History of European Societies," in *Enterprise and Secular Change: Readings in Economic History*, ed. Frederic C. Lane and Jelle C. Riemersma (Homewood: George Allen & Unwin, 1953), 494–521.

“planetary scale” was at the center of scientific and navigational enterprises.⁵ Historians of these ocean surveys have argued that such measurement “was mathematical and uncommunicative,” and that navigators such as James Cook “trusted techniques and instruments rather than people who had no particular reason to trust him.”⁶ According to these historians, the maps made during surveys of the northeastern Pacific in the 1790s “framed ... a distinctively British and scientific domain” through an impersonal calculus of instruments and measurements.⁷ Yet at the same time, these cartographic projects were integrated into ceremonial forms of social interaction. Whenever a marine chronometer was used to determine longitude at sea, the triple locks that sealed its ceremonial container had to be simultaneously opened by three different officers, its rate of going ritually recorded, its status sacralized. “Our trusty friend the watch,” as Cook called it.⁸ Very often instruments acquired personal names that made their makers and users present even as they were at work in measurement.⁹ They were thus embedded in a social system linking persons and devices in a very complex web of ceremony and politesse.

Such instruments were often taken and used by indigenous people; but we also need to understand what these people took them to be. On the Alaskan coast in June 1791, a group of Spanish astronomers who had arrived from Acapulco built an observatory to orient themselves. The Tlingit people, led by their chief Xune, approached the observatory, which subsequently became a privileged site of barter. The expedition’s commander recorded the following in his log:

*I do not know whether any of the many natives who approached the observatory understood the religious ideas concerning the Sun by which I attempted to give some color to our astronomical observations.*¹⁰

5. Marie-Noëlle Bourguet and Christian Licoppe, “Voyages, mesures et instruments. Une nouvelle expérience du monde au Siècle des lumières,” *Annales HSS* 52, no. 5 (1997): 1115–51; Vincent Jullien, ed., *Le calcul des longitudes. Un enjeu pour les mathématiques, l’astronomie, la mesure du temps et la navigation* (Rennes: PUR, 2002); Philippe Despoix, *Le monde mesuré. Dispositifs de l’exploration à l’âge des Lumières* (Geneva: Droz, 2005).

6. Nicholas Thomas, *Discoveries: The Voyages of Captain Cook* (London: Allen Lane, 2003), 7.
7. Daniel W. Clayton, *Islands of Truth: The Imperial Fashioning of Vancouver Island* (Vancouver: UBC Press, 2000), 198.

8. *The Journals of Captain James Cook on his Voyages of Discovery*, ed. John C. Beaglehole, vol. 3, *The Voyage of the Resolution and the Adventure, 1772–1775* (Cambridge: Cambridge University Press, 1961), cxii.

9. The reliability of an instrument as it traveled depended a great deal on the reputation and quality of the manufacturer—so much so that it was often referred to by his name. A quadrant was thus known as “Bird” or “Ramsden,” a timepiece as “Bréguet” or “Kendall.” The value and utility of the instrument was judged according to these appellations.

10. *The Malaspina Expedition 1789–1794: The Journal of the Voyage by Alejandro Malaspina*, ed. Andrew David et al. (London: Hakluyt Society, 2001–2004), 2:117 and 133, where the astronomical quadrant is described as a sacred “palladium.” See Frederica de Laguna, *Under Mount Saint Elias: The History and Culture of the Yakutat Tlingit* (Washington: Smithsonian Institution Press, 1972), 144 and 151.

Some encounters provided the occasion for surprising and important ritual practices. When the eminent hydrographer and administrator Charles-Pierre Claret de Fleurieu put together a long account of a 1792 Pacific fur-trade voyage, he was able to identify the Marquesas Islands using a chart originally made for Cook by a Polynesian priest and navigator, Tupaia:

*No doubt the correctness of Cook's or La Pérouse's charts is not required in those of a native of the Society Islands, who navigates in a canoe, without any means of measuring the rate of his progress, without any instrument to observe his latitude, without a compass to steer by? It must not be forgotten that he has no precise idea, no comparative measure of distances.*¹¹

Claret de Fleurieu nevertheless placed far more faith in “the correctness of Tupaia’s hydrography” than in that of French seamen, whom he castigated for their ignorance of the proper rituals of maritime measurement carried out using marine chronometers and lunar tables: “it is time to rouse French navigators from the humiliating apathy which keeps them in the shackles of an old routine.”¹² The inversion was thus complete: a reliably exact Polynesian, hopelessly traditional Frenchmen.

This kind of inversion of presuppositions, if not prejudices, with respect to the distinction between tradition and reason has become rather commonplace among histories of science that pay close attention to the way practices are located in specific contexts. Historians of science are concerned with the ways that techniques serve as mediators at moments of encounter and exchange between different kinds of sociability. Measurement seems transcendent, and thus effortlessly capable of universal mobility, solely and precisely because it appears not to depend on ordinary resources such as instruments made of metal, wood, or paper, or on humble practitioners such as sailors, merchants, and workmen. Historians of the sciences, however, have shown that measurement practices and values are local and mundane. They do not depend on especially inspired or excessively rational methods, but rather rely on the situated work of persuasion and credibility and are thus closely linked to the places in which they are carried out.¹³ These places are specially organized for these practices and, in turn, contribute to reinforcing their importance.

11. Charles-Pierre Claret de Fleurieu, *Voyage around the World Performed during the Years 1790, 1791 and 1792 by Étienne Marchand* (London: T. N. Longman et al., 1801), 1:256–57.

12. *Ibid.*, 1:258 and 2:231; Odile Gannier, “Consigner l’événement: les journaux du voyage de Marchand (1790–1792) et les *Isles de la Révolution*,” *Annales historiques de la Révolution française* 320 (2000): 101–20; Glyndwr Williams, “Tupaia: Polynesian Warrior, Navigator, High Priest—and Artist,” in *The Global Eighteenth Century*, ed. Felicity A. Nussbaum (Baltimore: Johns Hopkins University Press, 2003), 38–51.

13. See Simon Schaffer, preface to *La fabrique des sciences modernes, XVII^e–XIX^e siècle*, trans. Frédérique Ait-Touati, Loïc Marcou, and Stéphane Van Damme (Paris: Éd. du Seuil, 2014), 8.

Such claims point to problems of localization and displacement. How do measures that work in such locales work anywhere else, and in principle everywhere else? One key technique is *calibration*. This process consists in placing a scale of measurement on an instrument by exposing it to a well-known signal, then marking its responses. The crucial assumption is that the device will be able to measure unknown variables if, and only if, these variables are of the same nature as the signal used to calibrate the instrument.¹⁴ A balance, a sextant, or a thermometer works on the assumption that unknown entities have gravitational, optical, or thermal properties just like those used to calibrate the instrument. This assumption is a form of *social regulation*, because it is a shared convention that governs how collective measurement proceeds and allows new ways of engaging with the world.¹⁵ When measures are called into question, these shared conventions suddenly become apparent. They thus define an entire world and its boundaries, since they stipulate in advance what kinds of phenomena can be measured, and, through this process, known and mastered.

The Silent Trade

In some ways, all measurement practices are rituals because they demand careful attention to a sequence of performative actions without which the measure loses value. For navigators and assayers, accountants and merchants, the instructions that accompany tools of measurement are vital resources, especially when measurements are in dispute. A specific measurement is associated with a specific social setting, and through the mediating work of calibration, measurements accompany particular conceptions of the universe. In *The Royal Touch*, his great study of the emergence and decline of royal ceremonies of miraculous healing in medieval and early modern England and France, Bloch concluded that “truth to tell, the notion of the royal miracle would seem to have been related to a whole ... outlook upon the universe.”¹⁶ The connection between the workings of the ceremony and the worldview it embodied was clear to Bloch because he was writing both the history of a ritual practice and a history of belief in the efficacy of that practice. He understood that the way power is displayed is also a kind of power.

One of the most brilliant historians of money and coinage in medieval and early modern European markets, Bloch showed that measures do not easily travel. They are bound by the regimes that simultaneously helped define the properties of reliable knowledge and the contents of the world. These definitions were just

14. Harry M. Collins, *Changing Order: Replication and Induction in Scientific Practice* (London: Sage, 1985), 100–106.

15. Dominique Pestre, *À contre-science. Politiques et savoirs des sociétés contemporaines* (Paris: Éd. du Seuil, 2013), 43–57.

16. Marc Bloch, *The Royal Touch: Sacred Monarchy and Scrofula in England and France* [1924], trans. J. E. Anderson (Montreal: McGill Queen’s University Press, 1973), 216.

as fragile as the extension of the social order in which they were inscribed,¹⁷ which is why we need to abandon ethnocentric histories of measurement's progress. Yet, especially in accounts of the rationalist triumphs of modern sciences, measurement practices have often been understood as one of the most important factors in the homogenization of societies and as a powerful way of establishing effective communication and relations of domination between groups with different social structures. There is a very long tradition of considering measures as the most effective way of *delocalizing* social difference. According to historians of ancient commerce, for example, "the interweaving of the economic and the social" made it extremely difficult to develop common criteria of value among communities with contrasting social structures—it was thus essential to define measures that were autonomous and transcended specific localities, amounting to the negation of mediation.¹⁸ In the fourth book of his *Histories*, Herodotus tells of a land "beyond the pillars of Hercules" where Carthaginian merchants engaged in a strange but reassuring gold trade.

*[These travelling merchants] unload their cargo; then having laid it orderly along the beach they go aboard their ships and light a smoking fire. The people of the country see the smoke, and coming to the sea they lay down gold to pay for the cargo and withdraw away from the wares. Then the [Carthaginians] disembark and examine the gold; if it seems to them a fair price for their cargo, they take it and go their ways; but if not, they go aboard again and wait, and the people come back and add more gold till the shipmen are satisfied. Herein neither party (it is said) defrauds the other; the [Carthaginians] do not lay hands on the gold till it matches the value of their cargo, nor do the people touch the cargo till the shipmen have taken the gold.*¹⁹

Although this classical tale of mute and fair barter continued to circulate over millennia, the location where it took place was never entirely fixed.²⁰ In the thirteenth and fourteenth centuries, Muslim scholars relayed stories from Mali and

17. Bloch, "The Problem of Gold in the Middle Ages," in *Land and Work in Mediaeval Europe: Selected Papers*, trans. J. E. Anderson (Berkeley: University of California Press, 1967), 186–229; Bloch, *Esquisse d'une histoire monétaire de l'Europe* (Paris: Armand Colin, 1954); André Burguière, *L'école des Annales. Une histoire intellectuelle* (Paris: Odile Jacob, 2006), 121–24.

18. Laetitia Grassin and Raya Ben Guiza, "Les mécanismes institutionnels du commerce extérieur dans l'Antiquité: le cas de Carthage," *Antiquités africaines* 38/39 (2002–2003): 345–54, here p. 350.

19. Herodotus, *The Persian Wars* 4.196, trans. Alfred Denis Godley (Cambridge: Harvard University Press, 1921), 2:399. See: Philip J. Hamilton Grierson, *The Silent Trade: A Contribution to the Early History of Human Intercourse* (Edinburgh: William Green, 1903), 47–48; Émile-Félix Gautier, "L'or du Soudan dans l'histoire," *Annales d'histoire économique et sociale* 7, no. 32 (1935): 113–23, here pp. 118–19; Lars Sundström, *The Exchange Economy of Pre-Colonial Tropical Africa* (London: Hurst, 1974), 22–31; Rainer Ertel, "'Stummer Handel' in ökonomischer Sicht," *Zeitschrift für Ethnologie* 106, no. 1/2 (1981): 93–98, here p. 95.

20. Timothy F. Garrard, "Myth and Metrology: The Early Trans-Saharan Gold Trade," *Journal of African History* 23, no. 4 (1982): 443–61, here p. 444.

other West African kingdoms concerning inland gold producers who, summoned by drums, would silently negotiate with Moorish traders from the north. The Venetian navigator Alvise da Cadamosto, in Portuguese service off the coast of Senegal in 1455–1456, recorded that a silent trade flourished in the interior. Many in Mali reckoned that the gold producers might even be born dumb.²¹ Cadamosto's story, drawing its authority from Herodotus, spread widely through Dutch, French, and British commercial networks in the seventeenth century. The mariner Richard Jobson, who sailed the Gambia river in 1620 and was persuaded to publish his stories by the London cleric Samuel Purchas in 1623, recounted familiar tales of a silent trade of salt for gold: "it is said, they have a just manner of trading and never see one another."²² During the seventeenth century, Guinea became one of the main supply points of this precious metal and the scene of competitive commerce between European traders who engaged in complex negotiations with the Akan peoples of the region.²³ The Europeans were well aware that the Akan did not control the origin of all this gold: "the gold they bring there is tied in little skins, each of which is a measure of weight."²⁴ In 1614, the Basel surgeon Samuel Brun gave the following account:

*A hut stands there, in which the goods remain until the imbally-people or frontier-people come to carry them away and lay the gold in little bowls in their place. When they are gone, the Akanists come, take the gold and go home again. Thus the Akanists do not see the traders who give them the gold for the goods. It is a great wonder that neither side deceives the other.*²⁵

This explains the significance of stories of silent, reliable, immediate trade taking place somewhere upcountry. Michael Hemmersam, a Nuremberg goldsmith in Guinea in 1639, claimed that they "trade ... without them seeing each other, for they imagine that they might die [if they did so]." Whether it was because they were secretive, or hideous, or congenitally mute, "the Negroes take [the goods] away and leave as much Gold. They are the truest dealing men in the world. I have not found so much faith, nor faithfulness, no not in Israel."²⁶

21. Paulo Fernando de Moraes Farias, "Silent Trade: Myth and Historical Evidence," *History in Africa* 1 (1974): 9–24, here pp. 11–14.

22. Richard Jobson, *The Golden Trade; or, A Discovery of the River Gambia and the Golden Trade of the Ethiopians* (London: Nicholas Bourne, 1623), 102–3; Edward W. Bovill, "The Silent Trade of Wangara," *Journal of the Royal African Society* 29, no. 113 (1929): 27–38, here pp. 31–33.

23. Timothy F. Garrard, *Akan Weights and the Gold Trade* (London: Longman, 1980), 71–80; Yann Deffontaine, *Guerre et société au royaume de Fetu (Efutu). Des débuts du commerce atlantique à la constitution de la fédération fanti: Ghana, Côte de l'or, 1471-1720* (Ibadan/Paris: IFRA/Karthala, 1993), 53–57.

24. Cited in Adam Jones, ed., *German Sources for West African History, 1599–1669* (Wiesbaden: Franz Steiner, 1983), 67.

25. Cited in *ibid.*, 89–90. See also de Moraes Farias, "Silent Trade," 18.

26. Jones, *German Sources*, 116. Cf. Luke 7:9 and Matthew 8:10.

Despite, or perhaps precisely because of, its mythic status, the story of the silent trade in African gold is a pertinent starting point for these reflections on ceremonies of measurement. The silent trade was defined by the principle that the parties never met, nor relied on any intermediary or overseer: it was believed that shared measures existed, even while the parties remained invisible and mute. Its history long functioned as the ideal type of the most primitive stage of commerce, a “utopian model” of reliable measures produced without any mediation.²⁷ According to Émile Durkheim, for example, “it might be asked whether markets are not the organized version of these initial exchanges” between parties that were “taboo for each other.”²⁸ Stories gathered from across the globe, from the Gold Coast and the Silk Route, from western Africa in 1455, Newfoundland in 1612, or from Ceylon in 1681, were used to underwrite a quasi-evolutionist model according to which the silent trade was seen by sociologists as “a preparation for exchange,” if not “the archetype of all exchange.”²⁹ Shared measures were allegedly established easily, via the immediacy of things whose calibration had already taken place, and not by the mediation of some social interaction. It was imagined that ceremonies of measurement were not preceded by any social institution and yet ultimately managed to generate such institutions. Some early twentieth-century scholars therefore sought the source of the market’s power in these stories of the silent trade. In reply, their opponents observed that “it is very unlikely such conventions could have been set up between people who did not already know of self-conscious and calculated exchange.”³⁰ This trade could also be linked to the ancient and very widespread distrust of merchant-travelers, often seen as hostile and foreign to the social order. The silent trade and its original measures, it was said, led to more advanced systems for determining values.³¹ Ethnographic and historical research has dramatically challenged the very existence of the silent trade as a cultural reality. Nevertheless, the notion of a system of measures of great trustworthiness and faithfulness, which did not seem to depend on any social network or

27. Stephen Greenblatt, *Marvelous Possessions: The Wonder of the New World* (Chicago: University of Chicago Press, 1991), 182 n. 34.

28. Émile Durkheim, review of Grierson, *The Silent Trade*, in *L'année sociologique* 8 (1903/1904): 483–86, here p. 485.

29. René Maunier, “Recherches sur les échanges rituels en Afrique du Nord,” *L'année sociologique*, n.s. 2 (1924–1925): 11–97, here p. 16; Georges Smets, “Le commerce silencieux,” *Bulletin de la classe des lettres et des sciences morales et politiques de l'Académie royale de Belgique*, 5th ser., 25 (1939): 119–31, here p. 122 (Ceylon); David Harris Sacks, “The Blessings of Exchange in the Making of the Early English Atlantic,” in *Religion and Trade: Cross-Cultural Exchanges in World History, 1000–1900*, ed. Francesca Trivellato, Leor Halevi, and Cátia Antunes (Oxford: Oxford University Press, 2014), 62–90, here pp. 73–76 (Newfoundland).

30. Smets, “Le commerce silencieux,” 124. See also: Grierson, *The Silent Trade*, 64–67 and 87–88; Bovill, “The Silent Trade,” 34–35.

31. Karl Polanyi, “Ports of Trade in Early Societies,” *Journal of Economic History* 23, no. 1 (1963): 30–45, here p. 34; Jean-Christophe Agnew, “The Threshold of Exchange: Speculations on the Market,” *Radical History Review* 21 (1979): 99–118; James Redfield, “The Development of the Market in Archaic Greece,” in *The Market in History*, ed. A. J. H. Latham and B. L. Anderson (London: Croom Helm, 1986), 29–58, here pp. 38–41.

system of mediation, and which in some way or another worked everywhere and anywhere, sustained the idea that measures express natural facts rather than socio-historical conditions.³²

If the silent trade ever took place, which is doubtful, it happened at sites of critical significance in world trade and exploitation.³³ In fact, the Guinea gold trade relied on exquisitely ingenious measurement systems, the magnificently crafted gold weights designed by Akan traders to measure out variable amounts of gold dust in the highly fraught transactions they conducted with European intermediaries. Very often, indigenous traders used weights of varying size depending on the social status of their trading partners, and they considered gold dust to be the medium of exchange, not an independent commodity.³⁴ Europeans criticized the Guinean traders because the Akan did not seem to understand that gold came originally from God, and also because they imagined that gold was the Europeans' God.³⁵ And yet somehow these Europeans managed to acknowledge the cunning agility with which the Akan manipulated weights used in measurement while at the same time insisting that the source of Guinea gold was dominated by a pervasive silent trade.

The tale of the silent trade was widespread throughout the markets of early modern Europe. The Anglo-Irish satirist and clergyman Jonathan Swift, for example, was obsessed with Guinea gold and familiar with some of the sources relating to the silent trade. These stories were even available in his own library in texts such as Purchas's *Hakluytus posthumus* (1625), which he used in the composition of *Gulliver's Travels*.³⁶ In Swift's narrative, the eponymous hero encounters professors at the Lagado Academy's language school who use objects to limit the damage inflicted on the lungs by speech, asserting that "since words are only names for things, it would be more convenient for all men to carry about them such things as were necessary to express the particular business they are to discourse on." These erudites carry bulging sacks of things with which to converse, and claim that "this invention ... would serve as a universal language, to be understood in all

32. Sundström, *The Exchange Economy*, 31; de Moraes Farias, "Silent Trade," 10 and 19; Philip D. Curtin, *Cross-Cultural Trade in World History* (Cambridge: Cambridge University Press, 1984), 12–13; Wilfred Dolfma and Antoon Spithoven, "'Silent Trade' and the Supposed Continuum between OIE and NIE," *Journal of Economic Issues* 42, no. 2 (2008): 517–26, here p. 524.

33. Pierre Vilar, *A History of Gold and Money, 1450–1920*, trans. Judith White (Atlantic Highlands: Humanities Press, 1976), 51.

34. Garrard, *Akan Weights*, 93 and 174–75; André Nitecki, *Equal Measure for Kings and Commoners: Goldweights of the Akan from the Collections of the Glenbow Museum* (Calgary: Glenbow Museum, 1982), 26; G. Niangoran Bouah, *L'univers Akan des poids à peser l'or*, vol. 3, *Les poids dans la société* (Abidjan: Nouvelles éditions africaines, 1984–1985), 18–22.

35. Pieter de Marees, *Description and Historical Account of the Gold Kingdom of Guinea* [1912], trans. Albert van Dantzig and Adam Jones (Oxford: Oxford University Press, 1987), 73 and 191.

36. Dirk Passmann, "Purchas and Swift: Where Horses Talk and Eagles Carry Men," *Notes and Queries* 31, no. 3 (1984): 390–91; Arthur Sherbo, "Swift and Travel Literature," *Modern Language Studies* 9, no. 3 (1979): 114–27.

civilized nations.”³⁷ This silent trade would thus promote a universal language of things to ease communication between nations of different tongues. Ultimately, it represents a way of asserting that calibration is not a local set of conventions, but a vast and universal system of immemorially absolute values.

Clearly, the utopia Swift satirized here was one in which measurements travel without mediators. The myth of the silent trade placed particular emphasis on the fact that such commerce was preternaturally honest, and (despite strong evidence to the contrary) never needed local agents. It has become common to associate the Lagado scholars’ use of objects with Swift’s attack on the early Royal Society and its dreams of a science of universal measures and inventory accumulation. What is more, the Royal Society was seen as the twin sister of the Royal Africa Company, the main agent of the slave trade. The satire also emerges directly from the Anglo-Irish experience of monetary crises in the measure of values.³⁸ Reference to the silent trade thus helps bring out an important aspect of what was at stake in Swift’s joke. In Lagado, the professors evidently assign too much and the wrong kinds of agency to things. They imagine, falsely, that things can communicate their values without go-betweens, and have embedded within them innate powers to guarantee measures.

This is *fetishism*. The concept of the silent trade—immediate communication through things—developed in Guinea, the very cradle, as William Pietz has splendidly demonstrated, of the notion of the fetish—the false attribution of power to things that in fact lack this power.³⁹ Andreas Ulsheimer, a Swabian protestant surgeon who traveled to Guinea in 1603–1604, made the following comparison:

*Just as the Papists annually on Corpus Christi Day go around their fields and bless them against storms, so the Guineans annually gather together in each and every village on a certain day in April and make their füstisse [fetish] or devil-images to honour their füstisse or false god, the Devil. These images are nothing but a heap of dirt squeezed together.*⁴⁰

Recounting his voyage to Guinea in 1699, the French trader Nicolas Villault similarly described such fetishes as “inanimate things, most often so filthy and ugly that one has no desire to touch them.”⁴¹ If fetishes had a privileged status in another culture, the measures established within their own culture enabled these

37. Jonathan Swift, *Travels into Several Remote Nations of the World by Lemuel Gulliver*, 2 vols. (London: Benjamin Motte, 1726), 2:76–77.

38. Gregory Lynall, *Swift and Science: The Satire, Politics and Theology of Natural Knowledge, 1690–1730* (New York: Palgrave Macmillan, 2012), 89–119; Mark Govier, “The Royal Society, Slavery and the Island of Jamaica, 1660–1700,” *Notes and Records of the Royal Society of London* 53, no. 2 (1999): 203–17.

39. William Pietz, “The Problem of the Fetish, II: The Origin of the Fetish,” *Res: Anthropology and Aesthetics* 13 (1987): 23–45; Michèle Tobia-Chadeisson, *Le fétiche africain. Chronique d’un “malentendu”* (Paris: L’Harmattan, 2000), 79–88.

40. Jones, *German Sources*, 36.

41. Nicolas Villault, *Relation des costes d’Afrique, appellées Guinée* (Paris: Denys Thierry, 1669), 262.

European travelers to determine values independent of this status: they could unmask fetishes as *mere lumps of matter*. It was considered that commodified things could be exchanged across any social boundary without changing their true value. They could thus be used to judge others against an apparently universal standard.

The Roots of Measurement

This tale of a decisive shift from local ceremonies to global sciences, whose measures work anywhere and in principle everywhere, has since dominated the history of measurement. Consider the splendid histories of the move from “the world of approximation to the universe of precision,” the title of a remarkable essay published by Alexandre Koyré in 1948 as part of a series of articles on “machinism.” According to Koyré, past societies failed to achieve technological modernity because they lacked the sense that the world could be precisely measured. “It was not the thermometer that was missing, it was the idea that temperature could be subjected to an exact measurement.”⁴² Koyré considered that regimes of calibration were responsible for the emergence of modernity. What kinds of social systems might allow or prevent the emergence of such a notion of exactitude? Replying to Koyré in the *Annales* in 1950, Lucien Febvre had an answer: he entirely accepted the assumption that calibration was missing from earlier societies, and added that what mattered was a reliance on testimony instead of immediate measurement. “The world of approximation, yes. But that does not go far enough. It was nothing less than the kingdom of hearsay.” According to Febvre, savants’ trust in and reliance on the stories of others long impeded the institutionalization of a strong sense of what was possible, and what was impossible, in nature.⁴³

But there is something misleading about an easy identification of the practices of precision measurement with a Weberian account of rationalization and disenchantment. Spectacular examples are furnished by measurement rituals performed by pilgrims to Jerusalem, as the historian Zur Shalev has demonstrated. The Temple of Solomon and other sacred sites were understood as embodiments of precision measures. Pilgrims were provided with length standards to calibrate the dimensions of their bodies against those of the holy sites, measurements that were sometimes also printed in their guidebooks. Cords measured carefully against such holy places were used as cures for bodily suffering. A vast number of seventeenth-century texts included detailed plans of the Temple and other sacred sites, and European cities were filled with scale models of exquisite precision designed to display divine measures.⁴⁴ Ritual practice, royal and divine power, and the

42. Alexandre Koyré, “Du monde de l’à peu près à l’univers de la précision,” *Critique* 4, no. 28 (1948): 806–23, here p. 814.

43. Lucien Febvre, “De l’à peu près à la précision en passant par ouï-dire,” *Annales ESC* 5, no. 1 (1950): 25–31, here pp. 30–31.

44. Zur Shalev, “Christian Pilgrimage and Ritual Measurement in Jerusalem,” in “La misura,” special issue, *Micrologus* 19 (2011): 131–50.

activities of measurement and exchange were linked. This was especially the case during the great struggles around what E. P. Thompson memorably termed the “moral economy” of agrarian society, struggles in which the rituals of grain measures became the site of conflicts about calibration, standards, and the economy in general.⁴⁵ These aggressive ceremonies of measurement worked in a similar way to what Michèle Fogel has astutely called “ceremonies of information,” the rituals through which the early modern state produced information via the exercise of power.⁴⁶ It was no doubt tempting for Koyré and his colleagues, great historians of the progressive transition to modern sciences, to suppose that the history of measurement involved a late but inexorable move from the local to the universal. Yet there must also exist cases where the possibility of delocalizing the ritualized practices of measurement remained closely determined by their local origin.

Historians of the sciences have always been obsessed by problems of incommensurability and impressed by the ways in which particular sets of scientific practices embody specific worldviews. What if we take the term *incommensurability* more literally? Witold Kula’s now-classic 1970 study of the social meaning of measurement institutions, *Measures and Men*, opens with comments on the historic links between the development of metrological systems and socioeconomic conditions.⁴⁷ He thus remarks that West African gold traders, “in whose economy the extraction of gold dust played a major part, had a very advanced system of weights.”⁴⁸ In his detailed analysis of European cultures’ passage from traditional measures, embodied in things, to abstracted, universal regimes such as the metric system, Kula traced the dehumanizing drive for objectivity and found its key moment in Revolutionary France. According to Kula, the ultimate victory of the meter depended on the satisfaction of two conditions: “the equality of men before the law and the alienation of the commodity.”⁴⁹ The politics of reason and of the commodity are unmistakable. Kula ended his work with a “postscript in praise of prefects.” Against François-René de Chateaubriand’s post-Revolutionary assault on the “petty tyranny” of the metric Jacobins, he sang the praises of the measured state:

*The prefects ... shall seek, and achieve, in the areas of their administrative competence, further unification of ever new perceptions among men. Many further achievements will yet redound to their credit. They shall continue to bring about a higher level of mutual understanding among people. And in the end, a time will come when we shall all understand one another so well, so perfectly, that we shall have nothing further to say to one another.*⁵⁰

45. E. P. Thompson, “The Moral Economy of the English Crowd in the Eighteenth Century,” *Past and Present* 50, no. 1 (1971): 76–136.

46. Michèle Fogel, *Les cérémonies de l’information dans la France du XVI^e au XVIII^e siècle* (Paris: Fayard, 1989).

47. Jean-Claude Hocquet, “Les mesures ont aussi une histoire,” *Histoire et mesure* 1, no. 1 (1986): 35–49, here pp. 35–36.

48. Witold Kula, *Measures and Men*, trans. Richard Szyreter (Princeton: Princeton University Press, 1986), 5.

49. *Ibid.*, 123.

50. *Ibid.*, 288.

This utopian vision of the silent trade has not yet quite been realized. Already, in a 1960 essay published in the *Annales*, Kula had argued that since “one of the byproducts of the sudden collapse of Europe’s political domination over the world was the universal adoption of the social model created by the very same Europe,” it followed that “the duty of history is ... to interrogate the past with the aim of discovering what led us to this unification.”⁵¹ Did he suppose that measurement’s path was secured forever? Probably not, though this has often been the ritualists’ dream, notably in the Revolutionary culture that Kula lauded, and which Mona Ozouf so brilliantly explored through its sacrificial and utopian ceremonies.⁵²

In some rituals of sacred power, what was at stake was the measured exchange of different commodities. While Febvre saw the roots of modern precision in the displacement of a social practice based on trust by that of immediate engagement with the rituals of measurement, other social scientists have emphasized the ritual origins of these very measurement practices. Instead of supposing that social order was achieved through the power of precision techniques, several anthropologists and mathematicians have argued that the widespread acceptance of measures was the result of a globally diffused system of rituals. Early twentieth-century classical scholars and comparative anthropologists such as James Frazer, Jane Harrison, and Arthur Hocart argued that there was a close and complementary relation between myth and ritual. The eminent American mathematician Abraham Seidenberg and others subsequently used this approach to seek the ritual origins of measurement. They argued that in some primordial fertility rituals, the principal participants ran the risk of being sacrificed and killed. These rituals were thus absolutely necessary, but also rather dangerous. As a consequence, sacrificial protagonists would appear in the ritual in the form of an equivalent token, rather than in person. Pebbles or coins, for example, would be used as substitutes for the sacrificed participant.⁵³

This explained—or so it was claimed—why in so many cultures there was a strong taboo on counting persons directly. “When thou takest the sum of the children of Israel after their number,” so Moses is instructed in Exodus 30:12, “then shall they give every man a ransom for his soul unto the Lord, when thou numberest them; that there be no plague among them, when thou numberest them.” Kula recorded a host of plebeian and peasant forms of distrust concerning counting and measuring, classing them as “superstitions” about the power of the census and of the balance.⁵⁴ A mass of ethnographic evidence relating to ceremonies of weighing the soul, drawn from classical sources and from early modern

51. Witold Kula, “Histoire et économie : la longue durée,” *Annales ESC* 15, no. 2 (1960): 294–313, here p. 313.

52. Mona Ozouf, *Festivals and the French Revolution* [1976], trans. Alan Sheridan (Cambridge: Harvard University Press, 1988).

53. Abraham Seidenberg, “The Ritual Origin of Counting,” *Archive for History of Exact Sciences* 2, no. 1 (1962): 1–40; Robert Ackerman, *The Myth and Ritual School: J. G. Frazer and the Cambridge Ritualists* (New York: Routledge, 2002), 89–118.

54. J. G. Frazer, *Folk-Lore in the Old Testament: Studies in Comparative Religion, Legend, and Law* (London: Macmillan, 1919), 2:555–63; Seidenberg, “The Ritual Origin of Counting,” 19–20; Kula, *Measures and Men*, 13–17.

central Europe, was accumulated by the mid-twentieth-century Austrian ethnographer Leopold Kretzenbacher. All this evidence was also used to emphasize the importance of the balance as a key part of the ritual of substitution. Such instruments, it was claimed, were ceremonial ways of establishing a reliable equivalence between the protagonist to be sacrificed and the offering made in the participant's stead. It was concluded that these rituals were principally embodied in such basic and ancient measurement activities as the balance, the census, and the fiscal system. The divine monarch thus became the agent who calculated taxes as a substitute for counting subjects' persons directly.⁵⁵

This remarkable account of the relation between ritual and the origins of measurement was explicitly designed to bolster a diffusionist version of cultural anthropology and to counter the claims of modish mid-twentieth-century structural functionalism. It is not my aim here to pursue the ambitions of this universal ethnography of a globally diffused ritual system, which perhaps tells us more about the history of human sciences than the practices of past measurements. It is nevertheless possible to see how local practices of measurement were tied up with specific ceremonies of offering and sacrifice. In forging his account of the relation between ritual practice and royal power, Bloch explicitly engaged with the work of Frazer and his peers, and in 1922 Frazer was presented with an honorary doctorate at the University of Strasbourg, where Bloch worked. In the ambitious program for comparative history that he published in 1928, Bloch discussed the common approach adopted by Enlightenment philosophers and by Frazer, a perspective that considered societies spatially remote from European modernity to be comparable with those of primitive peoples.⁵⁶ In his brilliant 2010 Marc Bloch lecture, Carlo Ginzburg rightly emphasized that "before rejecting comparative ethnography, which he associated with Frazer, Bloch explored it as a legitimate alternative."⁵⁷ Bloch made lengthy manuscript notes designed to explain the faults of Frazer's method. He carefully distinguished Frazerian comparative ethnography from "comparative history within a limited horizon," where it was a question of tracing ritual practices in societies that were often in close contact with each other.⁵⁸ "One must beware," he wrote, "of making the ... mistake of transposing the Antipodes to Paris or to London."⁵⁹ Nevertheless, we must attempt to understand what happened when such transportation did indeed occur within the context of colonial and world circulations, and what kind of measures were derived from and applied to such remarkable displacements.

55. Abraham Seidenberg and James Casey, "The Ritual Origin of the Balance," *Archive for History of Exact Sciences* 23, no. 3 (1980): 179–226.

56. François-Olivier Touati, *Marc Bloch et l'Angleterre* (Paris: Boutique de l'histoire, 2006), 83–84; Bloch, "Toward a Comparative History," 498.

57. Carlo Ginzburg, "Lectures de Mauss," trans. Martin Rueff, *Annales HSS* 65, no. 6 (2010): 1303–20, here p. 1304.

58. Bloch, "Toward a Comparative History." The English translation does not include the footnotes, where this citation occurs. See the original French version: Bloch, "Pour une histoire comparée des sociétés européennes," *Revue de synthèse historique* 46 (1928): 15–50, here p. 19, n. 2.

59. Bloch, *The Royal Touch*, 30.

Royal Rituals

Let us consider one of Bloch's specific examples of a measurement ritual. Following Jacques Le Goff, Ginzburg pointed out the striking absence in *The Royal Touch* of any reference to the work of Marcel Mauss, whose essay *The Gift* appeared a year after Bloch's book.⁶⁰ At the very center of his study of medieval kingship and ritual healing, Bloch included a striking analysis of an English ceremony that explicitly linked the ceremony of the gift, measurement, balance, and royal authority. From the thirteenth century, every Good Friday the English king would "creep" toward an altar on which stood the cross. At the foot of the altar he would place a quantity of fine gold and silver coins. "Then he would take up these coins again—'redeem' them, as it was called—and replace them by an equivalent sum in any ordinary coin," normally twenty-five shillings.⁶¹ Rings were then forged from the precious metal so exchanged, and from at least the fifteenth century these were treated as curative talismans, especially potent against epilepsy, the sacred disease. According to a fifteenth-century account, the healing power of the "gold and silver devoutly touched and offered by the sacred anointed hands of the kings of England upon Good Friday, during divine service (according to the ancient custom of the kings of England) ... has been proved by frequent trial of rings, made of the said gold and silver and placed on the fingers of sick persons in many parts of the world."⁶²

These cramp rings, as they were called in reference to epilepsy, became an important element in English diplomacy. In 1510 the English ambassador to Emperor Charles V asked for cramp rings to be sent from London to the Habsburg ruler. Five years later, a Genoese spy working in Paris asked for a dozen rings to sell to wealthy Frenchmen, while the English ambassador in France claimed that Parisians had offered him twice their worth for these blessed rings.⁶³ With the accession of Elizabeth I to the English throne in 1558, the entire ceremony of ritual exchange and blessing ceased. Instead, English people started to make rings for themselves and for the medical marketplace. According to Bloch, in the first phase "the center of the action was a sort of juridical procedure, the offering of the gold and silver coins and their redemption by means of an equivalent sum."⁶⁴

60. Le Goff made this remark in a preface to the 1983 French edition of *The Royal Touch*, not included in the English translation: Jacques Le Goff, preface to Bloch, *Les rois thaumaturges. Étude sur le caractère surnaturel attribué à la puissance royale particulièrement en France et en Angleterre* (Paris: Gallimard, 1983), xxxv; Ginzburg, "Lectures de Mauss," 1304.

61. Bloch, *The Royal Touch*, 93.

62. Raymond Crawford, "The Blessing of Cramp-Rings: A Chapter in the History of the Treatment of Epilepsy," in *Studies in the History and Method of Science*, ed. Charles Singer (Oxford: Clarendon Press, 1917–1921), 1:165–88, here p. 171.

63. Bloch, *The Royal Touch*, 185.

64. *Ibid.*, 97.

Just as comparative ethnographers argued that the ritual of the balance had emerged from the need to establish a ceremonial equivalence between the sacrificial victim and the substituted offering, so, according to Bloch, “in order to make the offering serious, and so efficacious, the gift could only be redeemed by a payment, just as when something is bought from its legitimate owner.”⁶⁵ However, Bloch also explains how, in a second phase, the English monarchs seized power over the ceremony by positioning themselves as the masters of the rings’ efficacy. From the sixteenth century on, the rings were made in advance, their powers attributed solely to ritual contact between the rings and the monarch’s anointed hands. The system of ritual equivalence was abandoned or forgotten. With this appropriation of power by the monarchy, the sacred metal could no longer be considered as subject to a process of measurement: “the old practice of the simulated gift and redemption had almost lost its meaning.”⁶⁶

Bloch’s astute analysis of the ceremony of the cramp rings highlights the roles that rituals of measurement could play in the work of politics and of public knowledge. He particularly focused on changes in what might be called “trials of strength,” in which the staging of a relation of equivalence was connected with the display of forms of official power. The quantitative experimental method, which Koyré and Febvre saw as a major achievement of early modernity and as a decisive break with earlier traditions of ritual performance, nevertheless emerged from these public ceremonies. The importance of the balance and of what Mauss called “body techniques” in this set of practices was decisive. As Bloch pointed out, the English monarchy exploited and transformed a ceremony of miraculous measures by displacing attention from the work of balanced exchange toward the presence of sacred bodies. Habsburg monarchs were likewise invested in these kinds of transformations. Charles V set up a public balance where those accused of dealing with the devil could be weighed, then issued with a certificate of moral cleanliness. In the early seventeenth century, his grandson Philip III gave four times his weight in gold, and seven times his weight in silver, as an offering for the survival of his ailing son.⁶⁷ In institutional spaces such as churches, mints, academies, and courts, public assays simultaneously dramatized a moral order and a measure of royal authority over the powers of nature and the state.

The royal rite of weighing the body as an element in assays of monarchical power and moral order was by no means limited to European kingships. It was also familiar in the stories of Orientalists, who recounted the long tradition of balancing the bodies of South Asian rulers against a range of precious commodities. From as early as the Gupta period, during the fourth century CE, monarchs would be weighed against precious metals and the equivalent in grains or other commodities given as gifts to the poor. In the 1500s, just as the Tudors seized control of the cramp ring ceremony, so Mughal rulers, keen to identify themselves with perennial traditions of South Asian monarchy, resuscitated and developed these

65. *Ibid.*, 98.

66. *Ibid.*, 105.

67. Seidenberg and Casey, “The Ritual Origin of the Balance,” 198.

ceremonies, holding twice-yearly, large-scale ceremonial weighings of the monarch's body and charitable offerings, and extending the practice to the ruler's sons and honored courtiers.

According to the Persian text of the *A'in-i-Akbari*, composed around 1590 by Abū'l-Faẓl ibn Mubārak, eminent advisor to the emperor Akbar, the ruler would be weighed against a range of substances, including gold, mercury, iron, silks, perfumes, medicines, and grain, before the great potlatch of ritual gift giving.⁶⁸ Very significantly, Abū'l-Faẓl began his treatise with a long account of the workings of the imperial Mint. Describing successive currency reforms by Mughal ministers, he insisted that "the edifice of the world" was based on the successful practices of the fiscal system and its rituals. At the very start of a natural history of the Mughal court's administrative system, he tabulated the specific gravities of a vast range of substances, explained how alloys were smelted, and offered a cosmology of metallurgy.⁶⁹

The text, and the ceremonies it described, corresponded to an image of ideal equilibrium between a landed elite and the commercial system as it was reshaped during the sixteenth century. The significance of such ceremonies of alloying and weighing were familiar to the sixteenth-century Portuguese chronicler Fernão Mendes Pinto, who included them in his book of travels through Asia.⁷⁰ Thomas Roe, the English ambassador to Jahangir's court at Agra in 1616–1617, gave a very detailed if slightly quizzical account of the ritual of Mughal bodily measurement:

*I understood his weight to be nine thousand rupees, which are almost one thousand pounds sterling. After [he was weighed] with gold and jewels, and precious stones, but I saw none; it being in bags, [it] might be pebbles.*⁷¹

Roe's chaplain, who also witnessed the scene, made the obvious Biblical analogy with the fall of Babylon to the Persians, then drew a politically savvy conclusion:

*When I saw [Jahangir] in the balance I thought on Belshazzar, who was found too light. By his weight, of which his Physicians yearly keep an exact account, they presume to guess of the present estate of his body, of which they speak flatteringly, however they think it to be.*⁷²

The trope became commonplace in the accounts of Orientalists interested in the complex systems of accumulation and trade in South Asia. In his posthumously

68. Abū al-Faẓl ibn Mubārak, *Ayēen Akbery, or the Institutes of the Emperor Akber*, 3 vols., ed. and trans. Francis Gladwin (Calcutta: 1783–1786), 1:279.

69. *Ibid.*, 1:50–54.

70. Muzaffar Alam and Sanjay Subrahmanyam, "L'État moghol et sa fiscalité, XVI^e–XVIII^e siècles," *Annales HSS* 49, no. 1 (1994): 189–217, here pp. 197–98; Seidenberg and Casey, "The Ritual Origin of the Balance," 198.

71. William Foster, ed., *The Embassy of Sir Thomas Roe to the Court of the Great Mogul, 1615–1619*, 2 vols. (London: Hakluyt Society, 1899), 2:412 [spelling lightly modernized].

72. *Ibid.*, 411. Cf. Daniel 5:27.

published *Travels in the Mogul Empire*, François Bernier described the emperor Aurangzeb's weighing ceremony in the 1660s:

*On the third day of the festival, the king, and after him several omrahs [emirs], were weighed with a great deal of ceremony in large scales, which, as well as the weights, are, they say, of solid gold. I recollect that all the courtiers expressed much joy when it was found that Aureng-Zêbe weighed two pounds more than the year preceding.*⁷³

It was from Bernier, indeed, that in the *Lettres persanes* Montesquieu would later draw his condemnation of royal excess and political tyranny:

*When I see the subjects of the Mogul running in crowds once a year, to behold their king putting himself in a balance and causing himself to be weigh'd like an ox; when I see them rejoicing at their prince's being grown more corpulent, that is to say, less capable of governing them; I can't help pitying the extravagance of the mind of man.*⁷⁴

Montesquieu's characteristic acuity recognized that such public assays in rituals of measurement had major political significance: "this prince is a great magician"⁷⁵ was the citation from *Lettres persanes* that Bloch chose as an epigraph for *The Royal Touch*. Montesquieu's reflexivity recognized, too, that despite their exoticism these lessons directly applied to European realms as much as to oriental ones.

Trials of Value

To shed light on the roles such measurement rituals played within and between the global trade systems of the epoch, it is useful to return to Guinean gold. Two closely interwoven phenomena allegedly took place in the same locations: the silent trade, in which persons who could not understand each other established measurement through things, and superstitious fetishism, in which things that could not make themselves understood were covertly measured through persons. For English traders such Roe's colleagues, this gold would end up as a central part of a measurement ceremony entirely comparable with those of the cramp rings and the royal touch. At exactly the same moment that these great rituals of kingly power were first institutionalized, and in precisely the same locations, the English regime also established measurement ceremonies around the gold coinage manufactured from Guinea metal.

Linked very closely with the workings of the Royal Mint at the Tower of London and the center of royal power in Westminster, the Trial of the Pyx was

73. François Bernier, *Travels in the Mogul Empire A.D. 1656–1668*, trans. Irving Brock (London: William Pickering, 1826), 1:308.

74. Montesquieu, *Persian Letters*, trans. John Ozell, 3rd ed. (London: J. Tonson, 1736), 1:124 (letter 38).

75. *Ibid.*, 1:72 (letter 22).

so-named for the box in which randomly selected coin samples were stored before being tested. This ceremony was first recorded in the middle of the thirteenth century and was held regularly from the fourteenth century on. It was thus contemporary with the inauguration of the royal rituals of touching scrofula victims and of the manufacture of cramp rings. Indeed, the pyx itself was originally the box in which wafers were held before the Mass. It was guarded by three locks, as was common for many similar systems combining security and sacred ritual, including the marine chronometers that accompanied mariners on ocean voyages. The box was supposed to contain a leather bag of coins taken from each *journée*, or period of production of about fifteen pounds of gold. Each bag's contents were weighed before being tried by fire by a chosen jury of goldsmiths who had sworn a solemn and ceremonial oath. The minted coins were calibrated against a standard gold plate, and a sample of that plate was also put apart and stored in the Chapel of the Pyx in Westminster Abbey.⁷⁶

The Trial of the Pyx was sometimes a moment when the king personally surveyed and evaluated the values of the coins made at the Royal Mint. The resemblance between the offerings of coins made during the ceremony of the rings and that of the Pyx was close, for the royal prerogative was presented as the fount of the entire system of good values. Crucially, this public assay linking the monarch's person with the measurement of metal was designed to determine the value of gold coinage while at the same time publically establishing that this gold's value could be trusted by the state. As Pierre Vilar points out in his masterly *History of Gold and Money*, there was a significant coincidence between the currency stabilization of 1696–1714, a trebling of excise revenue in 1693–1714, and the reinforcement of a triangular trading system linking Guinea, Brazil and the Caribbean, and the European markets.⁷⁷ There was an intimate connection between this ceremony to determine the value of gold, the Guinea trade, and the development of measures on a world scale.

From 1696, the Mint was managed by Isaac Newton, natural philosopher and servant of the state, who was especially active during the period of the so-called Great Recoinage. He insisted on strict accuracy in weighing and sought to correct what he judged to be an unacceptably large tolerance of error in the average weight of coins—if the gold pieces tried in the Pyx ritual were too light, the loss was to be made up at the expense of the Mint's master, Newton himself. In 1710, for example, he protested at the quality of the standard with which the goldsmiths compared the gold coins.⁷⁸ In Newtonian London, as in Guinea, enormous power could be attributed to inanimate substances if, and only if, they were subject to

76. Simon Wortham, "Sovereign Counterfeits: The Trial of the Pyx," *Renaissance Quarterly* 49, no. 2 (1996): 334–59, here pp. 346–49; Stephen M. Stigler, "Eight Centuries of Sampling Inspection: The Trial of the Pyx," *Journal of the American Statistical Association* 72, no. 359 (1977): 493–500, here pp. 493–94.

77. Vilar, *A History of Gold and Money*, 222.

78. John Craig, *Newton at the Mint* (Cambridge: Cambridge University Press, 1946), 48–49; Isaac Newton, *Correspondence*, ed. A. Rupert Hall et al., 7 vols. (Cambridge: Cambridge University Press, 1959–1977), 5:82–83.

the right set of measurements. It is no coincidence that the first English narrative to have a potent object as its main character was Charles Gildon's *The Golden Spy*, printed in 1709, whose eponymous protagonist is a guinea coin made of West African gold. Measurement and its ceremonies dominated the public culture of the Newtonian world.⁷⁹

As master of the Mint, Newton was deeply involved in the Trial of the Pyx, the Guinea trade, and their various measurement rituals. While he worked at a major center of world commerce, he also sought to ground ritual measurement in a long history of providential cosmology. It was his vast research on the dimensions of the Temple of Solomon that furnished Newton with the connection between these two domains. He certainly witnessed models of the Temple on show in London and, like Swift, read closely in travelers' tales from Africa and the Levant. He shared the view that the sacred books encoded descriptions of precision rituals under the cover of myths. A detailed analysis of the measurements of the Temple followed, to be published in his writings on the sacred cubit. In these inquiries, Newton set out to prove that the ancients had known the true system of the universe and had celebrated this cosmology through the exact measures of their temples.⁸⁰ A history of measurement ceremonies was therefore welded to what the historian Colin Kidd calls "ethnic theology," the major eighteenth-century enterprise to understand the ways in which inhabitants of the ancient world in Asia, Africa, and Europe had managed to construct world networks of commerce and exchange between cultures.⁸¹

Newton's early eighteenth-century efforts to calibrate the values of coined gold in the Pyx ceremony and the dimensions of ancient measurements were contemporary with his attempts to calibrate measurements gathered from across the world. In 1712–1713, for example, he and his colleagues were engaged in producing a new version of the *Principia mathematica*, in which worldwide evaluations of very different measures of length and time, made by French travelers in the Antilles and South America, or by the agents of trading companies in India and China, were incorporated into a new "system of the world."⁸² The Newtonians were also much concerned with measuring the densities of a whole range of substances both at the Mint and in the assay rooms. The only way that Newton could

79. Charles Gildon, *The Golden Spy, or A Political Journal of the British Nights Entertainments of War and Peace, and Love and Politics* (London: J. Woodward and J. Morphew, 1709); Jonathan Lamb, *The Things Things Say* (Princeton: Princeton University Press, 2011), 40.

80. Isaac Newton, "A Dissertation Upon the Sacred Cubit of the Jews and the Cubits of the Several Nations," in *Miscellaneous Works of Mr John Greaves*, ed. Thomas Birch (London: Brindley and Corbett, 1737), 2:405–33; Jean-François Baillon, "Les écrits sur la religion d'Isaac Newton," in "Histoire et éthique des sciences et techniques," special issue, *Cahiers d'Épistémé* 1 (2006): 27–39; Tessa Morrison, *Isaac Newton's Temple of Solomon and his Reconstruction of Sacred Architecture* (Basel: Birkhäuser, 2011).

81. Colin Kidd, *British Identities before Nationalism: Ethnicity and Nationhood in the Atlantic World, 1600–1800* (Cambridge: Cambridge University Press, 2004), 10–23.

82. Simon Schaffer, "Newton on the Beach: The Information Order of *Principia Mathematica*," *History of Science* 47 (2009): 243–76.

prove the *Principia*'s most important claim—that all matter responds to gravity in the same proportion—was by testing the movements of balances and pendulums made with “silver, lead, glass, sand, common salt, wood, water and wheat,” using gold as the substance against which all other substances were calibrated.⁸³

Following these experiments on a whole range of very diverse objects and matters, the role of the balance and the pendulum in the rituals of enlightened measurement, established in Newtonian natural philosophy, was to become essential. The very same techniques were incorporated into the most important public rituals of the assay offices and national excise systems of eighteenth-century states. As Kula argued, “the creation of a ‘measure’ is a complex mental act. ... The qualitative diversity of cheese, butter, honey, wool, and nails is so great, and the traditional techniques of production so varied ... that they blinded contemporaries to the fact that these products do share the common property of weight.”⁸⁴ In his assays of just such a range of goods, Newton did much more than execute “a complex mental act.” He used the rituals of assaying to show that weight could indeed be considered, and then defined, as a “common property.” The establishment of this kind of social order, which could conceivably produce reliable and transportable techniques and results, required a regulated network of commodity exchange, and, in turn, helped to secure it.

For example, the tobacco leaf, whose commodity status depended on tight government regulation of barrel size, became a reliable commodity through the stringent rituals of the British excise laboratories. As in Britain, the leaf became part of the purchasing system of the French Farmers General, who monopolized its import from Virginia via Glasgow. It was thus the stock-in-trade of eighteenth-century fiscal experts such as Antoine Lavoisier, who inspected tobacco outlets, controlled the excise on goods entering Paris, monitored inflows and outflows of goods through the excise wall he constructed round the capital, and helped plan a national munitions industry. For Lavoisier and his collaborators, as Bernadette Bensaude-Vincent has shown, “the balance marked out a new space at the heart of the laboratory, almost like the sanctuary of a church.”⁸⁵ The term “sanctuary” is apt, for the figure of the balance embodied in a single set of practical performances an entire range of social meanings linked to the domains of accountancy and commerce, politics and morals: “the gestures of weighing performed by Lavoisier resonated with other practices of reckoning, inventorying, and algebraization in other cultural spheres that were implicitly mobilized every time Lavoisier appealed to the judgment of the balance.”⁸⁶ Moreover, these “gestures of weighing” were systematically and ingeniously incorporated into rituals of political performance.

83. Isaac Newton, *The Principia: Mathematical Principles of Natural Philosophy*, trans. I. Bernard Cohen and Anne Whitman (Berkeley: University of California Press, 1999), bk. 3, proposition 6, p. 453.

84. Kula, *Measures and Men*, 43.

85. Bernadette Bensaude-Vincent, *Lavoisier. Mémoires d'une révolution* (Paris: Flammarion, 1985), 85–86.

86. *Ibid.*, 201 and 215.

Between 1783 and 1785, the French king and his ministers, academicians, and administrators became privileged witnesses of Lavoisier's synthesis and analysis of water. In a manner redolent of much older state ceremonial, the chemists sought to persuade their elite public of the fact of water's gaseous composition. Historians agree that these rituals were qualitatively persuasive. But they also agree that Lavoisier improvised backstage with the material of his calculations until they seemed convincing.⁸⁷ Ceremonies of measurement implied a certain amount of work behind the scenes in order to assure that calculus and theatre matched.

As Kula's arguments suggest, it was in the domains of commerce and agronomy that such rituals mattered most. The conflicts between rival accounts of the moral economy hinged on the values invested in calibrating price, quantity, and production. For the peasants who supported a traditional view of the moral economy, the agricultural market was supposed to be governed by a moral code, sanctioned by custom and Scripture. Agricultural labor transferred the divine product of God's earth from soil to table. Whoever intervened in this process by trading in the sacred territory between the fields and the home was guilty of a sort of blasphemy. In 1759, according to Kula, the royal procurator at Nantes announced that since "a variety of foodstuffs ... sold by the heaped measure" were sold in varying quantities because the substance was piled up within the receptacle that formed the standard measure, "it is therefore of consequence to the general public and in particular to those members of it [who] ... depend for their sustenance on low-grade grains ... that the actual dimensions of the Nantes *boisseau* be determined once and for all—its width and its depth."⁸⁸ Yet protests exploded whenever and wherever local and idiosyncratic rituals of grain measurement seemed to be violated.

Customary measures, embodied as examples in metal or wooden containers, were treated as sacred objects, supervised by authority, venerated by civic ceremony, and stored in treasured sites. In 1732, for example, the British government attempted to impose a standardized measure on the rituals for calibrating the weight of corn. A citizens' jury in the city of Gloucester carefully packed the new and legally validated container tightly with grain, then slowly poured its contents into the traditional measure, giving a bulkier but lighter and thus acceptable quantity of corn.⁸⁹ Think, as an apt comparison, of those seventeenth- and eighteenth-century Guinean markets where the Akan used weights that varied according to the social status of their commercial partners. Sometimes tools were introduced as a means of regulation. In 1753, for instance, the Swedish government commissioned an ingenious machine from the expert instrument maker Daniel Ekström that

87. Frederic Lawrence Holmes, *Lavoisier and the Chemistry of Life: An Exploration of Scientific Creativity* (Madison: University of Wisconsin Press, 1985), 214, 218, and 234.

88. Kula, *Measures and Men*, 60.

89. Richard Sheldon et al., "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. Adrian Randall and Andrew Charlesworth (Liverpool: Liverpool University Press, 1996), 25–45, here p. 34.

mechanized the process of pouring grain into a measured container, thereby—or so it was alleged—doing away with the need for careful manual management.⁹⁰ In a host of similar cases, measurement rituals were contested, adopted into custom, or treated as sacred.

The Invention of Metrology

In late eighteenth-century France, a new term designating the science of these measurement rituals and their world distribution was invented: *métrologie*. The term had previously been used, though only rarely, as a technical concept in mathematics. In the *Dictionnaire universel de mathématique et de physique* published by naval engineer Alexandre Savérien in 1753, metrology was simply defined as “elementary geometry.”⁹¹ Matters changed in 1780 with the work of Lavoisier’s contemporary, the Paris-based mathematics teacher Alexis-Jean-Pierre Pauton. Pauton’s treatise *Métrologie*, which eventually earned him the chair of mathematics at the University of Strasbourg, traced rituals of measurement throughout sacred and human history from the perspective of its central role in agronomy. The convergence of the social conflicts of his time with antiquarianism was very marked in Pauton’s extraordinary book, which began with a discourse on contemporary agronomy and the “flour war” of 1775, conducting experiments on the capacity of the grain measures then in use.⁹² Yet, like Newton, Pauton swiftly moved on to a long meditation on the virtues of the ancients, whom he believed had navigated the oceans and discovered America, as tales of a lost Atlantis proved.⁹³ He also considered that these ancients had constructed vast metrological monuments, and that the Great Pyramid, to which he also devoted a separate treatise in 1781, was the supreme embodiment of fundamental standards: “the pyramid is a monument that deserves to be examined anew; no other is so capable of shedding a great light on antiquity.”⁹⁴ Like Newton, Pauton considered that these standards, ritualized by antiquity and memorialized in its monuments, depended on an unrivalled mastery of the Earth’s dimensions. He thus recommended political and economic strategies akin to those of the physiocrats: the abandonment of colonial trade, which was a source of luxury and corruption, and its displacement by “the only riches that can make a people flourish and its population grow: the fruits produced by the native soil.”⁹⁵

90. Arne Hessenbruch, “The Spread of Precision Measurement in Scandinavia 1660–1800,” in Kostas Gavroglu, ed., “The Sciences in the European Periphery during the Enlightenment,” special issue, *Archimedes* 2 (1999): 179–224, here pp. 208–9.

91. Alexandre Savérien, *Dictionnaire universel de mathématique et de physique*, 2 vols. (Paris: Rollin/Jombert, 1753), 2:146.

92. Alexis Pauton, *Métrologie ou Traité des mesures, poids et monnoies des anciens peuples et des modernes* (Paris: Desaint, 1780), 568–602. See also Kula, *Measures and Men*, 90.

93. Pauton, *Métrologie*, 210.

94. *Ibid.*, 116.

95. *Ibid.*, 630; Arthur Young, *Travels in France during the Years 1787, 1788 & 1789* (Dublin: Cross, Wogan, 1792), 2:45–46.

It would be easy but fundamentally erroneous to read Paucton's work as a clear symptom of modern rationality, and to treat its introduction of metrological vocabulary as nothing more than a prefiguration of the quantifying spirit in a pre-Revolutionary context. In fact, as the vast and politically oriented scope of his project reveals, it was typical for Paucton and his contemporaries to construct very strong connections between measurement techniques, administrative and social crises, and conjectural histories of measurement as a world principle. It is certainly true that metrology's methods would eventually become indispensable to social historians. Bloch prophesied that "a time will come ... when no study of regional life, whether by a historian (in the standard sense of the word) or a geographer, will be conceived ... without maps of measurements."⁹⁶ But in the more immediate term, it became a weapon for a range of political and economic interests. In the 1770s, Paucton appropriated older traditions of Orientalist scholarship, especially reports of travelers in the Levant and South Asia who gathered comparative information on measurement practices across markets and courts. Very close comparisons could be made, therefore, between Newtonian measurement rituals and Paucton's metrology. British merchants and colonial administrators exploited the relationship between these rituals and metrology within newly reorganized global trading systems. Between 1777 and 1783, for example, an East India Company revenue collector and printer in Calcutta, Francis Gladwin, organized the translation of substantial extracts from Abū'l-Fazl's *A'in-i-Akbari*, so that what was taken to be a guidebook to Mughal measures, with its details on the management of the Mint, the origin of precious metals, and the ceremonial weighing of the monarch, could be made accessible to the British regime. As Kapil Raj has argued, this was neither the first nor the last administrative attempt to extract useful fiscal information from Abū'l-Fazl's treatise.⁹⁷ The declared aim of Gladwin's project was partly to allow the regime to claim it had adopted and displaced former ceremonies and practices of measurement and law. In complete reliance on local experts in Persian and Mughal administrative traditions, British scholars published voluminously on Indian systems of weights and measures.

The East India Company used these principles to establish a "permanent settlement" of farm and property rights. This violent reorganization of measures was decisive in the reorganization of Bengal agronomy in 1793. The Company considered that "a patient and laborious scrutiny of individual rights, together with a minute and detailed survey of the extent, cultivation and productive powers of the territory [was] indispensable."⁹⁸ After 1795, the financier and administrator Henry Colebrooke produced a major analysis of Indian weights and measures,

96. Marc Bloch, "Le témoignage des mesures agraires," *Annales d'histoire économique et sociale* 6 (1934): 280–82, here p. 282.

97. Kapil Raj, "Mapping Knowledge: Go-Betweens in Calcutta, 1770–1820," in *The Brokered World: Go-Betweens and Global Intelligence 1770–1820*, ed. Simon Schaffer et al. (Sagamore Beach: Science History Publications, 2009), 105–50, here p. 130.

98. Sarvepalli Gopal, *The Permanent Settlement in Bengal and its Results* (London: Allen and Unwin, 1949), 24. See also Ranajit Guha, *A Rule of Property for Bengal: An Essay on the Idea of Permanent Settlement* (Paris: Mouton, 1963), 13.

linking this with his accounts of indigenous astronomy, celestial mechanics, and cosmology.⁹⁹ In 1814, the Moravian missionary and botanist Benjamin Heyne, who had worked since 1800 in the newly conquered territories of Mysore as a plant collector and surveyor, published his remarkable statistical account of Indian measurement practices. Almost all of Heyne's records were produced in close collaboration with Brahmin informants, who could apparently recite Telugu versions of Sanskrit works on land mensuration by heart. They detailed the relation between body techniques, traditional measures, and the demands of economic and social administration. Heyne stressed the great accuracy of the wide range of measures in use at the time, explained the rituals that defined units of weight, length, or area, and argued that although "the introduction of English measures would be commodious for Europeans," this transformation of values would expose "the lower classes of Indians ... to great imposition."¹⁰⁰ In the relations that Europeans sustained with the indigenous experts on whose measurement practices they relied, it is certainly not true that measurement belonged to one side, tradition to the other.

It was thus no coincidence that the word "metrology," designating the science of measurement rituals, at last entered the English language. It first appeared in the works of the East India Company's principal Mint administrator, James Prinsep, and of the mathematics teacher Patrick Kelly. Following Heyne's statistical accounts, Prinsep conducted a census of all the different measurement systems at work in the subcontinent that he could collect, and commissioned models of each set of standards based on surveys of measurement systems in India. Kelly's aim was to produce universally valid reckoners for coinage values, weights, and measures across the global commercial system. Prinsep thus sent his models from Calcutta to London as part of a calibration program completed in 1823 and published by Kelly in 1832 with a title that was both eloquent and, for the British, unprecedented: *Oriental Metrology*.¹⁰¹

Metrology thus entered the British world through India. Debates subsequently broke out concerning the ritual basis of such measures and the challenges of uniformity. Prinsep, who urged that standardization could "only be done in the gradual process of time, by the growing inter-communion of the multitudes engaged in the internal traffic of the country,"¹⁰² was opposed by a Bombay military surveyor and fierce evangelical, Thomas Jervis, who argued for the centralized imposition of measurement standards throughout British India. It would be easy

99. Rosane Rocher and Ludo Rocher, *The Making of Western Indology: Henry Thomas Colebrooke and the East India Company* (Abingdon: Routledge, 2012), 24–32.

100. Benjamin Heyne, *Tracts, Historical and Statistical, on India* (London: Robert Baldwin, 1814), 172–80, citation p. 80. See Kapil Raj, *Relocating Modern Science: Circulation and the Construction of Knowledge in South Asia and Europe, Seventeenth to Nineteenth Century* (Delhi: Permanent Black, 2006), 69.

101. Patrick Kelly, *Oriental Metrology; Comprising the Monies, Weights, and Measures of the East Indies and Other Trading Places in Asia, Reduced to the English Standard by Verified Operations* (London: Longman, 1832), 11; James Prinsep, *Useful Tables, Part the First: Coins, Weights and Measures of British India* (Calcutta: Baptist Mission Press, 1834), 75–77.

102. Prinsep, *Useful Tables*, 75.

but misguided to see Prinsep as the conservative, Jervis as the rationalizer. If anything, the opposite was true: using arguments resembling those of Newton, Jervis found the basis for all measurements of length in ancient sources, especially the Bible. For him, universal and ancient measurement ceremonies had been developed in the Levant by divine inspiration and thence diffused worldwide. “The universality and simplicity of the scriptural scheme of metrology,” Jervis argued, would allow the effortless legal imposition of this system throughout the empire.¹⁰³ “The poor unlettered *ryot*, or cultivator, the needy and despised heathen,” would, he predicted, easily see how a moralized system of metrology would protect against exploitation and embed him or her in the imperial system of values.¹⁰⁴ From this point on, imperial metrology and the significance of sacred rituals and monuments, whether in Europe, India, or Egypt, seemed evident, especially to the colonial powers.

This is the end of a journey that began on the northern Pacific coasts and has led, via the royal ceremonies of European and Mughal rule and the politico-economic interests of antiquarians and Enlightenment experimenters, to the concerns of the Indian administration at a moment of world economic and political crisis, illuminated by a Telugu version of a Sanskrit text on measurement, or by an evangelical engineer’s interpretation of Jewish metrology. In his article “Hearing Voices,” Sanjay Subrahmanyam rightly insists that “modernity is historically a global and conjunctural phenomenon, not a virus that spreads from one place to another.”¹⁰⁵ This article has aimed to move in a similar direction, to restore a certain kind of symmetry to the long-term workings of measurement and to escape the sense of a linear and monotonic progression toward precision as part of an inevitably modern order. By placing measurement ceremonies within a more heterogeneous historical geography, it also becomes possible to see how Bloch’s analyses of ritual practices and conceptions of the universe can be justly applied to the story of the modern sciences. These histories show that supposedly silent traders in fact spoke in many different voices.

Simon Schaffer
University of Cambridge

103. Thomas B. Jervis, *Records of Ancient Science Exemplified and Authenticated in the Primitive Universal Standard of Weights and Measures* (Calcutta: Baptist Mission Press, 1835), 86.

104. *Ibid.*, xiii; see Matthew H. Edney, *Mapping an Empire: The Geographical Construction of British India, 1765–1843* (Chicago: University of Chicago Press, 1997), 268–87.

105. Sanjay Subrahmanyam, “Hearing Voices: Vignettes of Early Modernity in South Asia, 1400–1750,” *Daedalus* 127, no. 3 (1998): 75–104, here pp. 99–100.