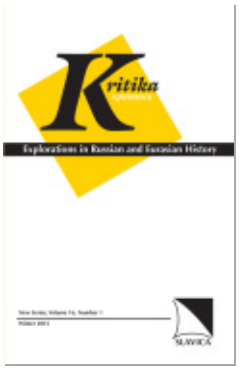
Measure of All the Russias: Metrology and Governance in the Russian Empire



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Kritika: Explorations in Russian and Eurasian History, Volume 4, Number 4, Fall 2003 (New Series), pp. 783-815 (Article)

Published by Slavica Publishers
DOI: 10.1353/kri.2003.0058

Articles

Measure of All the Russias

Metrology and Governance in the Russian Empire

MICHAEL D. GORDIN

"It is hard in a few words to conceive the sorry state in which weights and measures are found in Russia," grumbled Learned Storekeeper V. S. Glukhov of the Depot of Exemplary Weights and Measures in St. Petersburg in 1889.[1] Charged with maintaining aging samples of standard units of length, weight, and volume, Glukhov felt understaffed, underequipped, and underappreciated. Just twenty years later, John Hill Jurigs, retired from the Indian Civil Service, wrote from England with a quite different message, alternately charged with optimism and imperialism, to Nikolai G. Egorov, the director of the Chief Bureau of Weights and Measures (*Glavnaia palata mer i vesov*—GPMV): "There seems to be a strong reason for believing that railways can conveniently act as pioneers of the metric system by using metric weights before that system has come into general use among the people. I am thus strengthened in the

I would like to thank Peter Galison, Loren Graham, Karl Hall, Matthew Jones, John LeDonne, and Skuli Sigurdsson for comments on earlier drafts of this paper. A portion of the project was completed with support from a travel grant from the Davis Center for Russian Studies at Harvard University.

Abbreviations: ADIM—Arkhiv-Muzei D. I. Mendeleeva (D. I. Mendeleev Archive-Museum); *MS*—Dmitrii Ivanovich Mendeleev, *Sochineniia*, 25 vols. (Leningrad: Izd. AN SSSR, 1934–54); *PSZ—Polnoe sobranie zakonov Rossiiskoi Imperii* (St. Petersburg: Tipografii II Otdeleniia Sobstvennoi Ego Imperatorskago Velichestva Kantseliarii, 1830); *PSZ* 2*—Polnoe sobranie zakonov Rossiiskoi Imperii: Sobranie vtoroe* (St. Petersburg: Tipografii II Otdeleniia Sobstvennoi E. I. V. Kantseliarii, 1830–84); *PSZ* 3*—Polnoe sobranie zakonov Rossiiskoi Imperii: Sobranie tret'e* (St. Petersburg: Gos. tip., 1885–1916); RGIA—Rossiiskii gosudarstvennyi istoricheskii arkhiv (Russian State Historical Archive); and *VGPMV—Vremennik Glavnoi Palaty mer i vesov*. Dates follow the old-style Julian calendar, which lagged 11 days behind the Western calendar in the 18th century, 12 in the 19th, and 13 in the 20th. Exceptions are indicated by (N.S.).

[1] V. S. Glukhov, "Zapiska o sostoianii Depo obraztsovykh mer i vesov i voobshche o merakh i vesakh v Rossii," 28 December 1889, RGIA f. 28, op. 1, d. 167, ll. 1–7, on l. 1ob. Throughout this article, I translate the Russian "measures and weights" as "weights and measures," which is more euphonious for the English speaker.

Kritika: Explorations in Russian and Eurasian History 4, 4 (Fall 2003): 783–815.

hope that before long we may see the Kilogram carried by Russian railways to the Pacific ocean and the gates of India."[2] In the last years before World War I, metrology—the science of weights and measures—and its connection to governance had become so regularized in Russia that there was hope that the emerging universal standard, the metric system, would take root across the expanse of Asia.

The transition to which Jurigs pointed was largely the product of a change in management from Glukhov to Egorov's predecessor, the distinguished chemist Dmitrii Ivanovich Mendeleev (1834–1907), best known for his 1869 formulation of the periodic table of chemical elements. The development of Russian weights and measures from an era of rampant fraud and lack of coordination to a metrological regime deemed to be one of the most advanced in the world was a haphazard development that took almost 200 years to accomplish, and it went through most of the fluctuations in governance and politics experienced by the Russian empire more broadly. Mendeleev, more than any other individual, appropriated elements of that vast tradition and transformed it into a coherent vision of a metrological Russia. This article explores the history of the standardization of weights and measures in imperial Russia, documenting how the gradual transformations in metrology displayed in miniature more general trends in the structure (or lack thereof) of Russian governance, and how the increasing definition of standardization in terms of the metric system, especially in the last two decades of tsarism, represented an episode in the integration of Russia into the organization of European powers.

At first glance, perhaps nothing seems more dry and impervious to historical analysis than a system of weights and measures. Yet every system of weights and measures requires an elaborate infrastructure built on convention, trust, and enforcement to ensure that the specified measures actually hold. In the case of Russia, the traditional measures (see Table 1) correlated only loosely with the other two modern systems of measurement (the British and the metric), and the conversion values fluctuated widely in different periods. Even the relations within the Russian system of measures varied according to local, and eventually imperial, practices. Once a system is defined, then the authorities, whoever they may be, must ensure that those measures are employed in trade and administration, and that the exemplars of those weights ("standards") do not deteriorate with time or use. All this makes for a continuous regime of governance that blends legal, traditional, punitive, commercial, technological, and scientific considerations in a manner characteristic of a particular place and time. The story of Russia merits a separate accounting for several reasons:

[2] John Hill Jurigs to N. Egorov, 14 August 1909, RGIA f. 28, op. 1, d. 362, l. 29.

Table 1. **Russian Measurements Relative to the British and Metric Systems**

Measured	Russian System	British System	Metric System
Length	1 *sazhen* = 3 *arshins*	7 feet	2.1336 meters
Distance	1 *verst* = 500 *sazhens*	3,500 feet = 0.66 miles	1.0668 kilometers
Mass/Weight	1 *funt*	1 pound	0.454 kilograms
Large weights	1 *pud*	40 pounds	18.16 kilograms
Volume	1 *vedro*	3.28 gallons	12.420 liters

Source: Elena Ivanovna Kamentseva and Nikolai Vladimirovich Ustiugov, *Russkaia metrologiia*, 2nd ed. (Moscow: Vysshaia shkola, 1975), chap. 4.

These conversions are those established by the 1899 standardization law. Under earlier regimes, different exact correlations were considered standard.

its idiosyncratic system of measures, its role in the development of the metric system, and the peculiarities of the Russian state in enforcing uniformity in the imperial period.

There has recently been increasing interest, especially among historians of science and technology, in the role metrology has played in the establishment of regimes of political and economic control and in the cultural definition of the category of precision, a noteworthy addition to the literature on historical weights and measures.[3] The neglect of a social history of metrology in the

[3] See, in particular, Witold Kula, *Measures and Men*, trans. R. Szreter (Princeton: Princeton University Press, 1986), 210–11, 238; Ken Alder, "A Revolution to Measure: The Political Economy of the Metric System in France," in *The Values of Precision* (Princeton: Princeton University Press, 1995), ed. M. Norton Wise, 39–71; Maurice Crosland, " 'Nature' and Measurement in Eighteenth-Century France," *Studies on Voltaire and the Eighteenth Century* 87 (1972): 277–309; Charles-Edouard Guillaume, *Unités et Etalons* (Paris: Gauthier-Villars et fils, 1893); and Adrien Favre, *Les Origens du Système Métrique* (Paris: PUF, 1931). On British metrology, see Simon Schaffer, "Late Victorian Metrology and Its Instrumentation: A Manufactory of Ohms," in *Invisible Connections: Instruments, Institutions, and Science*, ed. Robert Bud and Susan E. Cozzens (Bellingham, WA: SPIE Optical Engineering Press, 1991), 23–56. The Prussian case is less frequently mentioned. There the values of precision measurement were tied to an efficient bureaucracy and public morality. In addition, after the formation of the internal tariff union, the *Zollverein*, weights and measures became de facto standardized between the various German states, which greatly facilitated German unification. See Kathryn M. Olesko, "The Meaning of Precision: The Exact Sensibility in Early Nineteenth-Century Germany," in *The Values of Precision*, ed. Wise, 103–34; and William Hallock and Herbert T. Wade, *Outlines of the Evolution of Weights and Measures and the Metric System* (New York: Macmillan, 1906), 86. On American metrology, see Joseph O'Connell, "Metrology: The Creation of Universality by the Circulation of Particulars," *Social Studies of Science* 23 (1993): 129–73.

Russian case is particularly lamentable, since the enormity of the land mass made correlation of the periphery with the center more crucial. During the Soviet period, historians and metrologists wrote a series of excellent works documenting the changes in measures, but with little attempt to integrate those transformations with the political and social history of the Russian empire.[4] It is the aim of this essay to correct this oversight and demonstrate how closely linked metrological reform was with the dilemmas of "formalization" that plagued the Russian empire.[5]

It is not, however, my purpose to provide a history of the metric system in Russia. The metric system was one of several competing systems of weights and measures in Russia throughout the 19th century, at precisely the moment when the state turned increasing attention to this issue, and thus this system and its advocates play a prominent role in what follows. In fact, the influence of Russian advocates of metric measures on European events will be underlined on several occasions. But the Russian empire collapsed with only optional employment of this system, and metric measures were eventually imposed by force by the Bolshevik regime in 1918. In the conclusion, I address some of the relevant history but do not offer a detailed account of this

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The literature on historical metrology is vast, mostly emphasizing monetary measures, which I do not address here. For more on this topic for Russia, see: F. I. Petrushevskii, *Obshchaia metrologiia* (St. Petersburg: Eduard Prats, 1849); Petr Grigor′evich Butkov, "Ob′′iasnenie russkikh starinnykh mer, lineinoi i putevoi," *Zhurnal Ministerstva vnutrennikh del* 8 (1844): 247–93; A. I. Nikitskii, "K voprosu o merakh v drevnei Rusi," *Zhurnal Ministerstva narodnogo prosveshcheniia* 292 (1894): 373–420; Gleb Vladimirovich Abramovich, "Neskol′ko izyskanii iz oblasti russkoi metrologii XV–XVI vv. (korob′ia, kopna, obzha)," *Problemy istochnikovedeniia* 11 (1963): 364–90; Illarion Ignat′evich Kaufman, *Russkii ves, ego razvitie i proiskhozhdenie v sviazi s istorieiu russkikh denezhnykh sistem s drevneishikh vremen* (St. Petersburg: Imp. Akad. Nauk, 1906). I also set aside the issue of standardizing time, which is well treated in Peter Galison, *Einstein's Clocks, Poincaré's Maps: Empires of Time* (New York: Norton, 2003).

[4] Nikolai Aleksandrovich Shost′in, *Ocherki istorii russkoi metrologii, XI–nachalo XX veka*, 2nd ed. (Moscow: Izd. standartov, 1990); Elena Ivanovna Kamentseva and Nikolai Vladimirovich Ustiugov, *Russkaia metrologiia*, 2nd ed. (Moscow: Vysshaia shkola, 1975); Mikhail Nikolaevich Mladentsev, "Kratkii istoricheskii ocherk russkikh mer," *VGPMV*, no. 8 (1907): 176–84; and T. F. Gapeeva and M. N. Moshkova, "Iz istorii razvitiia rossiiskoi sistemy mer i vesov," in *D. I. Mendeleev—osnovopolozhnik sovremennoi metrologii*, ed. Valerii Vasil′evich Boitsov (Moscow: Izd. standartov, 1978), 27–49.

[5] The literature on "formalization"—the set of processes to establish a systematic state structure—in Russia is somewhat dated. See Edward C. Thaden, ed., *Russification in the Baltic Provinces and Finland, 1834–1914* (Princeton: Princeton University Press, 1981); George L. Yaney, *The Systematization of Russian Government: Social Evolution in the Domestic Administration of Imperial Russia, 1711–1905* (Urbana: University of Illinois Press, 1973); and Marc Raeff, *The Well-Ordered Police State: Social and Institutional Change through Law in the Germanies and Russia, 1600–1800* (New Haven: Yale University Press, 1983).

transition. The history of Soviet metrology, including the introduction of the metric system, presents a fruitful topic of investigation and would likely offer a similar vantage point into the methods and philosophies of governance of the Soviet regime. My focus here, however, is to articulate how particular metrological decisions—especially the empirewide metrological laws—reflected the regime's broader attitudes toward governance. Of course, the international context played an important role here, especially as the metric system increased in importance; and the dialectical relation of Russian scientists, and later the Russian state, in international measures that *politically* drove the metric movement is emphasized.

A second caveat concerns the relation of *metrology* to *standardization*. Most simply put, the former is a subset of the latter. This is an article about metrology, not standardization. The Russian empire continually experimented with different mechanisms and philosophies of standardization in almost every realm (economic, legal, administrative, etc.). I occasionally refer to these specific standardizations to highlight affinities with what was happening in the more restricted area of metrological standardization of weights and measures. I argue that by focusing directly on metrology, one can see some of the broader standardization trends in clearer focus and thus acquire another tool to investigate the mechanisms of imperial governance. There is no claim of direct causation here: at times there may have been an immediate connection between the style of governance and metrology, at times not. More important for my purposes is to show that resonances existed, whatever their causes might be in each specific instance. I place particular weight on the Mendeleev period in Russian metrology for two reasons: first, the source base is substantially deeper, and thus one can draw a more complete picture of the various processes of standardization at work; and, second, Mendeleev's efforts highlight the connection between metrology and governance most explicitly.

Mendeleev's efforts, however, marked only the endpoint of a long imperial tradition.[6] Efforts to achieve uniformity in weights and measures were for the most part sporadic, one-time measures in imperial Russia. There were three exceptions: the standardization laws of 1797 (under Paul I), 1835 (under Nicholas I), and 1899 (under Nicholas II). As these laws reflect the general character of metrology in their periods, I examine each of them in turn, placing each in the general context of governance exhibited by the regime in power. The 1899 law is the most complex and detailed of the three, and I divide its story into two sections, the first treating the establishment of the Chief

[6] The Soviet regime, of course, itself built upon the tradition of Mendeleev's Bureau of Weights and Measures. (It even hired his son, Ivan, to perform some of the tasks of conversion to the metric system.) The discontinuities, however, were also substantial.

Bureau of Weights and Measures under D. I. Mendeleev, and the second Mendeleev's efforts to facilitate the introduction of the metric system. I end with a brief evaluation of the success of this reform (in imperial terms) and the universal imposition of the metric system by the Bolshevik regime in 1918.

1797: Police Metrology

The most striking changes to the administration of the Russian empire in the 18th century occurred during the reign of Peter the Great (1689–1725), but he died leaving the standardization of weights of measures in abeyance. Throughout the century, until Paul I (1796–1801) instituted the first imperial standardization edict, a series of monarchs instituted stopgap metrological measures, addressing separate aspects of the problems of accurate measurement (precision measurement, a separate matter, was not considered until a century later).[7] Although no single law carried out all the standardization work, all the relevant laws of this century, including Paul's, displayed the same general pragmatic qualities. An abstract need to standardize was recognized by various officials, and the government emphasized that such a reform should be instituted in the most economical and least politically disruptive manner possible.

Although Peter the Great did not undertake any overarching metrological reforms, lower officials began to adopt incremental types of standardization. In 1705, James Bruce, then director of the Artillery, adopted the standard Nuremberg measurements to redesign Russian munitions; and in 1719, Peter told his *voevody* they had to verify the accuracy of trading measures (although this was rarely enforced).[8] The first real state action on measurement issues was in the reign of Anna (1730–1740). Anna established the 1736 Commission on Weights and Measures under Director of the Mint Count M. G. Golovkin, who collected a great many regional prototypes. This commission was the first major European group to seek a decimal system of measure—in this case of the *sazhen*—although the commission was dissolved in 1742 (Golovkin having been arrested and exiled to Siberia in 1741 with the rise of Elizaveta Petrovna)

[7] The distinction between "accuracy" and "precision" is important. A measure is accurate if it corresponds to the real measure of the object in question. It is a property of the object measured. Precision is a function of the measuring instrument; it is the degree of certainty by which a particular measurement is made, usually indicated by significant digits. The two concepts are not co-extensive. Imagine a measurement of a person on an imprecise bathroom scale to be 80 kg, and a defective precision scale to give the measure of 85.2741 kg. If the person actually weighs 81 kg, the first result is more accurate, though less precise, than the second.

[8] Christopher Duffy, *Russia's Military Way to the West: Origins and Nature of Russia's Military Power, 1700–1800* (London: Routledge and Kegan Paul, 1981), 18; and Mikhail Nikolaevich Mladentsev, "Uchrezhdenie Glavnoi Palaty mer i vesov i eia deiatel′nosti," *VGPMV* 8 (1907): 1–49, on 3.

without having implemented any major reforms. Abolition of the commission did not end the metrological efforts. An example was the determination of the length of the *sazhen*. It was generally agreed that the *sazhen* was equal to seven English feet, but it was also traditionally divisible into three *arshins*. Although there was no state-sanctioned standard for the *sazhen*, there was a half-*arshin* (*poluarshin*) stored in Peter the Great's personal collection of scientific instruments. However, when six of these half-*arshins* were laid out, the result was roughly one inch longer than seven English feet, creating a dilemma between two traditional definitions of the *sazhen*. Instead of opting for measures linked to the British standard, the commission resolved in favor of the Petrine standard. This definition held until 1797.[9]

Isolated and uncoordinated decisions continued for the rest of the century. In 1747, a standard *funt* and *arshin* were proclaimed, although again with no enforcement. In 1753, internal tariffs within Russia were eliminated. Since trade was now able to flow freely between different parts of the empire, much in the manner of the later German *Zollverein*, it was easier (in principle) to unify units of trade between imperial districts.[10] Then, in 1754 and 1766, a series of edicts defined the proper procedure for measuring land. In an agricultural country where wealth was defined by the amount of land one possessed (and the number of serfs bound to that land), standardization of land measures was crucial.[11] The most substantial of the partial edicts of the 18th century were issued by Catherine II. On 7 November 1775, jurisdiction over weights and measures was parceled out to local authorities like the Lower Land Court (*Nizhnii zemskii sud*) in her major reform of local administration.[12] On 8 April 1782, Catherine's police regulation decreed that weights and measures had to be the same everywhere, although she did not bother to define those measures or how to determine "sameness." Local police maintained jurisdiction over metrological fraud.[13]

Catherine's son, Paul I, issued the first true standardization edict on 29 April 1797, following the pattern of the previous laws: pragmatic unification

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[9] Elena Ivanovna Kamentseva, "Mery dliny v pervoi polovine XVIII v.," *Istoriia SSSR* 6, 4 (1962): 127–31. On the 1736 commission, see Shost'in, *Ocherk istorii russkoi metrologii*, 122–23.

[10] Lev Vladimirovich Cherepnin, *Russkaia metrologiia* (Moscow: Istoriko-Arkhivnyi Institut, 1944), 77; and Kamentseva and Ustiugov, *Russkaia metrologiia*, 193. For a general history of this phase of imperial standardization, see Dmitrii Ivanovich Prozorovskii, *Moneta i ves v Rossii do kontsa XVIII stoletiia* (St. Petersburg: A. Transhel', 1865).

[11] Kamentseva and Ustiugov, *Russkaia metrologiia*, 11–12.

[12] *PSZ*, vol. 20, 14392, 228, 259.

[13] *PSZ*, vol. 21, 15379, 34, 114–15, 273.

under police powers. Article 1 clearly abolished nonstandard measures "for their ability to deceive."[14] The law preferred taking standards that already existed in some form and then declaring them legitimate official prototypes. The bulk of the law concerned not the standards but how to determine when fraud was occurring and how to punish it. Different degrees of punishment were meted out depending on how much money the fraud generated, instead of how inaccurate the standard was. New exemplars were to be made "according to a particular set of rules," without specifying either the rules or the materials (in practice they were made with cast iron and wood—rather imprecise materials). The law's goal was to preserve "uniformity and accuracy (*edinoobraziia i vernosti*)," so standards were elided in favor of implementation: which certification stamps should be employed, which measured subdivisions were legitimate in trade ("as few as possible"), and truth in labeling. In principle a flexible relation was instituted between the British and the Russian systems, but determinations of accuracy were delegated to the police, not to the emerging international canons of precision measurement. For example, on 19 September 1798, a division was set up in the Department of City Management in St. Petersburg (as opposed, for example, to the Academy of Sciences) to oversee standardization.[15] To provide partial enforcement in an empire with substantially constrained resources in the provinces, a law of 11 January 1798 declared that only weights made at the Aleksandrovskii factory, under the supervision of State Councillor Gaskonii, would be official. The goal, as in the fundamental law, was to lead to "the cessation of the means employed for deception and for the destruction of public trust."[16]

This emphasis of the 1797 law on police power is quite typical of Paul's reign in general, and of his militarization of government in particular. (This is not to say that economic concerns were not also of seminal importance, but they were underemphasized in the final law.) When Paul assumed the throne after his mother's death, his only articulated reform project was a reorganization of the Russian military along Grigorii Aleksandrovich Potemkin's uniform lines, followed by similar quasi-centralizing projects in communications and forestry.[17] Frederick the Great's systematizing reforms in

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[14] *PSZ*, vol. 24, 17938.

[15] Mladentsev, "Uchrezhdenie Glavnoi Palaty mer i vesov i eia deiatel'nosti," 6.

[16] *PSZ*, vol. 25, 18318.

[17] Kazimierz Waliszewski, *Paul the First of Russia, the Son of Catherine the Great* (Philadelphia: J. B. Lippincott, 1913), 155. Paul also established a Ministry of Communications (*Putei soobshcheniia*) in 1798, exactly contemporaneous with his standardization reforms. The language of the 27 February 1797 edict reflected a similar emphasis on local police powers. See *Kratkii istoricheskii ocherk razvitiia i deiatel'nosti Vedomstva Putei soobshcheniia za sto let ego*

Prussia—especially, but not exclusively, of the military—had a strong influence on Paul's own approach to ruling Russia as a *Polizeistaat*.[18] Ultimately, Paul's notion of system was not quite as developed as Frederick's, and the result of these reforms was just as frequently useless micromanagement as it was effective regulation. For example, Paul not only systematized the army, standardized weights and measures, and tightened up the bureaucracy, but he also banned the use of words reminiscent of revolution, monitored the decoration of houses, and regulated forms of dress.[19] The several elements of the militarization of Russian government under Paul reappeared in each of these systematizing reforms: first, a professionalization of the administrative apparatus; second, a struggle with corruption; and third, an obsession with "right rules" of conduct.[20]

Despite Paul's desire for systematicity and military rigor, even in weights and measures, there were several highly unsatisfying aspects of this first edict. It is worth emphasizing these, since in many respects the task of the next two waves of standardization was to rectify the flaws of the 1797 law. The first problem with the 18th-century program of standardization was its autarkic quality. From the debates on the definition of the *sazhen*, the state consciously chose to define measures without an external (read: foreign) reference point. Part of this concern was a desire not to be dependent on foreigners. There are, however, problems with defining standards completely internally. For one, it is extremely difficult to recalibrate damaged standards when their accuracy is solely dependent on the historical lineage of a single local prototype. And un-

sushchestvovaniia (1798–1898 gg.) (St. Petersburg: Tip. Min. Putei soobshcheniia, 1898), especially 7; and Alfred J. Rieber, "The Rise of Engineers in Russia," *Cahiers du monde russe et soviétique* 31 (1990): 539–68, on 540. On Paul's centralization of forestry control on 12 March 1798 from Catherine II's local treasury administrations, see *Ministerstvo finansov, 1802–1902* (St. Petersburg: Ekspeditsiia zagotovleniia gosudarstvennykh bumag, 1902), vol. 1, 49.

[18] Duffy, *Russia's Military Way to the West*, 200–1; Waliszewski, *Paul the First of Russia*, 100–1, 478; Mikhail Vasil'evich Klochkov, *Ocherki pravitel'stvennoi deiatel'nosti vremeni Pavla I* (Petrograd: Senatskaia tip., 1916), 111; and John L. H. Keep, "Paul I and the Militarization of Government," in *Paul I: A Reassessment of His Life and Reign*, ed. Hugh Ragsdale (Pittsburgh: University Center for International Studies, 1979), 91–103, on 92.

[19] Hugh Ragsdale, "Introduction," in *Paul I*, ed. Ragsdale, vii–xxiii, on xi; Evgenii Sevast'ianovich Shumigorskii, *Imperator Pavel I: Zhizn' i tsarstvovanie* (St. Petersburg: V. D. Smirnov, 1907), 103.

[20] Hugh Ragsdale, "The Mental Condition of Paul," in *Paul I*, ed. Ragsdale, 17–30, on 26; Keep, "Paul I and the Militarization of Government," 96, 99; and Klochkov, *Ocherki pravitel'stvennoi deiatel'nosti vremeni Pavla I*, 121. Perhaps unfairly, Karnovich argues that Paul did nothing for the civil service and internal governance, while focusing exclusively on military and foreign affairs. See Evgenii Petrovich Karnovich, *Russkie chinovniki v byloe i nastoiashchee vremia* (St. Petersburg: N. P. Soikin, 1897). This was clearly not true of metrology.

like the French experience with the metric system, as detailed by Ken Alder, where a new philosophy of governance and of political economy accompanied the new measures, the Russian units carried traditional conceptions of measurement with them, and thus were less amenable to rigorous redefinition.[21] Furthermore, one of the major goals of standardization is to make trade with foreign nations more regular (and thus more taxable). Explicit correlation with the English system of measures meant connections not just with England but with every trading nation that used those measures. Such counterproductive autarky in measures was ameliorated only by the fact that merchants ignored the state and continued to use British standards.

A second deficiency of the 1797 law was its irregular enforcement. Throughout the 18th century, various regions of the Russian empire were exempted from standardization—most notably the Baltic region, which was explicitly excluded from the 1797 law. Such exclusions were understandable—the Baltic littoral was left out of the standardization law because it was Paul's general policy to give them more autonomy in local administration—but later commentators have attributed the slow introduction of standard measures in Russia to precisely this fragmentation that characterized the economy.[22] In the 19th century, technological advances made it almost impossible to exclude certain parts of the state in favor of traditional autonomy. Finally, the 1797 law was too local in character. Recall that throughout the 18th century, reforms of standards were locally enforced, and sometimes even locally legislated. Paul's reform asserted the power to determine what those standards were but—as with his provincial reform—he did not centralize authority over them in St. Petersburg. If no single source set the standards, then in effect there were none. These faults would eventually set the agenda for future attempts at standardization.

This did not happen immediately. Even under Paul's systematic successor, Alexander I (1801–1825), the laws relating to weights and measures retained this police character. Local St. Petersburg city regulations of 24 June 1803 declared that weights and measures should be stored in wood cases and be employed to verify that no fraud was taking place, and that correct weights should be "stamped," but no mechanism was provided to ensure the validity of the weights, or even to define what the error tolerances were.[23] On 4 February

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[21] Such redefinition was, of course, not impossible, as the case of England (and later Russia) would demonstrate, but it did mandate greater attention to the details of reform. For Alder's analysis of the metric system and political economy, see his "A Revolution to Measure."

[22] See Kamentseva and Ustiugov, *Russkaia metrologiia*, 222.

[23] *PSZ*, vol. 27, 20816, II. 8. Such "stamping" was supposed to be under the jurisdiction of the Ministry of the Interior as of 17 August 1810: *PSZ*, vol. 31, 24326, v. 8.

1824, an edict was proclaimed regulating the production and distribution of standard *arshins*.[24] This law was designed to enforce another law of 28 June 1810 that set up a procedure of producing new *arshins* according to the specifications of Court Clockmaster Gainam.[25] Production from the first factory was closed down in 1821 after having produced over a million *arshins*; distribution was even more problematic. The idea of the 1824 law was to improve it by selling these *arshins* to private and public organizations across the empire (with the exception of Siberia), mandating that all government agencies should begin employing the new standard or face financial penalties. Production of *arshins* except in the Petersburg factory was criminalized.[26] Here one can begin to detect the breakdown of the older mode of police standardization and the transition into the second phase of administrative standardization. As became typical of administrative standardization, the production and exact measure of the *arshin* were specified, but the law excluded large portions of the empire, was locally enforced, and had no ethic of precision. The *arshin* law was both the last of the old laws and the first of the new ones.

1835: Administrative Metrology

The second quarter of the 19th century was in general a time of metrological standardization across Europe. In 1824, the British Parliament codified its system of measures, largely to counter the growing popularity of the metric system. In 1837, after years of forced imposition of (and reactions to) the metric system, it finally (and irreversibly) became the exclusive legal measure of France.[27] Thus when Nicholas I (1825–1855) began standardizing Russian weights and measures in 1835, his timing was impeccable. As in the police period, there were really several edicts of standardization in the "administrative" phase, all similar in nature. First, the state's emphasis was on the centralization of all metrological activities into the imperial bureaucracy, even if jurisdiction was not consolidated in one bureau. There was also a growing concern about

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[24] *PSZ*, vol. 39, 29760.

[25] *PSZ*, vol. 31, 24275. Jurisdiction here was fragmented. The Ministry of the Interior was to locate the appropriate factory, but the Ministry of Finance was to salary the mechanic. According to a law of 12 September 1818, the minister of justice had inquired as to whether 500,000 arshins would be sufficient, and turned jurisdiction of distribution to the Ministry of the Interior. *PSZ*, vol. 25, 27536. Such bureaucratic fragmentation was characteristic of infrastructural reforms in this period.

[26] Kamentseva and Ustiugov, *Russkaia metrologiia*, 216–17.

[27] On the British case, see Ronald Edward Zupko, *Revolution in Measurement: Western European Weights and Measures since the Age of Science* (Philadelphia: American Philosophical Society, 1990), 180–81. On France, see Cherepnin, *Russkaia metrologiia*, 12.

precision and a decreased emphasis on pragmatic concerns like fraud. Finally, the system defined itself in terms of foreign measures. These changes responded both to the inadequacies of 1797 and to new conditions.

The first new law was that of 11 October 1835.[28] In 1827, a Commission of Exemplary Weights and Measures had been erected "for the establishment on unchanging principles of a system of Russian weights and measures," including members A. I. Lamberti, V. K. Vyshnevskii, and Eduard Al′bert Kollins. After gathering and comparing many domestic and foreign prototypes of measures, the commission's work slowed down after Lamberti's death in 1830. In 1832–33, it was reorganized and expanded as the Commission for the Introduction of the Unitarity of Russian Weights and Measures. This new commission included the minister of the interior; representatives from the Ministry of Finance and the mining and monetary departments; Academician Adol′f Iakovlevich (Theodore) Kupfer; the Pulkovo observatory director, Friedrich Georg Wilhelm Struve; and the chief of the corps of military topographers, Fedor Fedorovich Shubert. This diverse grouping composed the 1835 statute.[29] After considering the various options, including introducing the metric or the British systems wholesale, the commission favored the status quo:

> The Russian Commission, following the example of the London Commission, posed as a principle that nothing would be changed in the weights and measures used in Russia. The introduction of a universal metric unit, like the meter of the French Commission, the purely geometrical nature of which would instantly as a result give rise to a national dispute, seemed to be one of those utopias that the human spirit loves to produce but that offer insurmountable difficulties in the execution.[30]

The law was rather short, and its general characteristics can be summarized in a few cardinal points. First, it specified the standards in detail. Conversely, there was little mention of economy and almost no mention of fraud, the two key motivating issues of 1797. Enforcement was deferred (until 1842), but

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[28] *PSZ* 2, vol. 10, 8459.

[29] Adolph Theodore Kupffer, *Travaux de la Commission pour fixer les mesures et les poids de l'empire de Russie* (St. Petersburg: Imprimerie de l'Expédition de la confection des papiers de la Couronne, 1841), v–vi; Shost′in, *Ocherk istorii russkoi metrologii*, 172; Kamentseva and Ustiugov, *Russkaia metrologiia*, 191. On the membership of these commissions and the history of their deliberations, see Kamentseva and Ustiugov, 219 and passim. On Lamberti's metrological work, see the rather cursory treatment in Lamberti, *O pervonachal′nom proiskhozhdenii i nyneshnem sostoianii rossiiskoi lineinoi mery i vesa* (St. Petersburg: Tip. Imp. Vospitatel′nago doma, 1827).

[30] Kupffer, *Travaux de la Commission pour fixer les mesures*, xvi.

several lengthy passages exactly determined the parameters of enforcement: precise demarcations of the materials, the size of the prototypes, and the temperature at which they were to be accurate. The materials, however, varied widely—copper, gilded copper, iron, and cast iron (none of which are especially precise), each tied to a specific measure. Perhaps most importantly, the fundamental unit, the *sazhen*, was defined in terms of the British system (seven feet), breaking the autarky of the old system. Then, in Western fashion, a *funt* was described as a certain volume of water at a specific temperature, determined by *sazhen*-based lengths (although the definition was rigged so that 1 *funt* exactly equaled 1 British pound). This meant that the prototypes stored in Petersburg did not *define* Russian measures; they *stood in* for prototypes stored elsewhere. As the commission reported in 1841:

> The linear measure in Russia is the same as that in England; there is only a difference in its divisions; the two empires, the power of whose commercial relations have extended further over the surface of our globe, have thus the same linear measure. In order that the linear English measure always be recoverable in case that it is lost, it has been compared to the length of a pendulum [that swings with a period] of one second at the latitude of London at sea level, a quantity that can be always recovered by observation; one can do the same thing, I fully affirm, for the Russian measure.[31]

Now that autarky was removed, the state was correspondingly more willing to disrupt local measures in the interest of uniformity, placing everything under imperial supervision, split between the Ministry of the Interior (MVD) and the Ministry of Finance (MF).[32]

This law was enforced by the ancillary protocol of 4 June 1842, which turned out to be the only standardization law for the next 57 years.[33] This law specified that copies of the standards established in the 1835 law were to be made, distributed, and used "in all parts of the empire" as of 1 January 1845. The exclusion clauses of 1797 were eliminated (although the Baltic region could still use local measures for internal affairs). The intent of the law was to ensure that the new prototypes were used everywhere, without regard to traditional measures. To accomplish this, the fragmentation of jurisdiction between

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[31] Kupffer, *Travaux de la Commission pour fixer les mesures*, xxvi.

[32] This split actually began in 1833, when control of weights and measures shifted from the Ministry of Finance to partial control by the Ministry of the Interior. See Kamentseva and Ustiugov, *Russkaia metrologiia*, 221. On the historic conflict between these two bureaus, see Yaney, *The Systematization of Russian Government*, 307–17.

[33] *PSZ* 2, vol. 17, 15718.

the MF and MVD was officially endorsed. A Depot of Exemplary Weights and Measures was created to store prototypes and was to be headed by a "learned storekeeper (*khranitel'*) from the membership of the Academy of Sciences, or among other persons who have a specialty in metrological concerns," further fragmenting jurisdiction. Local police and trade bureaus were to enforce the law; and all civil servants—architects, surveyors, notaries, tax collectors, and so on—were required, as agents of the MF or MVD, to use the measures and report violations.[34] The final part of the law micromanaged implementation: which materials could be used in copies of the standards, how those copies were to be made, and to what extent individuals could privately use unofficial measures. The law was explicitly integrated into the imperial law code; that is, its relevance to taxation codes, police enforcement, and trade regulations was specified.

In a deliberate change to the 1797 program of standardization, the commission specifically endorsed the need for an institution to control metrological activities in the empire: the Depot of Exemplary Weights and Measures. But, as Adol'f Kupfer pointed out in an official report, it was not enough merely to store exemplary weights and measures: a whole battery of measuring instruments must be stockpiled and a specialist—preferably a physicist—placed in charge. As holder of the chair in physics at the Imperial Academy of Sciences in Petersburg, Kupfer negotiated a salary for himself and assumed the post of learned storekeeper.[35] Kupfer even began scientific research at the Depot, using the measuring instruments stored there to research the expansion coefficients of metals.[36] While the establishment of the Depot was a move toward the institutional consolidation of metrological affairs, the institution itself was split between the MF and the MVD and was transferred wholly to the MF under the Department of Trade and Manufactures only as of 6 January 1869, years after Kupfer's death.[37] The bifurcated jurisdiction had troublesome consequences, as when Kupfer was denied permission to distribute exemplary weights to various cities by the MVD, despite previous authorization by the MF.[38] Even so, Kupfer had to work through the MVD

[34] On the distribution of standards to the various *gubernii*, see the order by Minister of Finance Egor Frantsevich Kankrin of 12 April 1838, RGIA f. 28, op. 1, d. 1, ll. 1–2ob.

[35] Kupfer to Director of Mining and Salt Affairs Beger, February 1843, RGIA f. 28, op. 1, d. 6, ll. 1–2. For more on Kupfer, see Vasilii Mikhailovich Pasetskii, *Adol'f Iakovlevich Kupfer, 1799–1865* (Moscow: Nauka, 1984).

[36] Kupfer special report, December 1843, RGIA f. 28, op. 1, d. 6, ll. 7–13.

[37] Mladentsev, "Uchrezhdenie Glavnoi Palaty mer i vesov i eia deiatel'nosti," 11.

[38] Director Lents of the Administrative Department, Ministry of the Interior, to Kupfer, 6 March 1847, RGIA f. 28, op. 1, d. 17, ll. 8–9ob.

when he wanted to find out what was happening at the local level, whereas the MF controlled the situation in Petersburg.[39] Kupfer had other travails to face given the general lack of coordination in international metrology. Without an international metrological bureau, such as the future International Metric Committee, Kupfer had to collect examples of foreign weights and measures and their conversions to the Russian system by himself, as did every other European state.[40] Nevertheless, Kupfer managed to mobilize some local Petersburg interests behind the project of metrological reform. Upon his death in 1865, there was no one of similar stature to fill the role; and V. S. Glukhov, a dedicated metrologist but an inadequate politician, assumed the role.

The 1835 law was motivated by a series of economic and technological concerns. In the 1830s, Russian statesmen began to feel the need for more precise measures of gold and silver in international exchange, besides a burgeoning industrial revolution in techniques of production. It was fine for textiles to be measured by the *sazhen*, give or take a tenth of an inch, but in machine industry, deviations of a hundredth of an inch could prove disastrous. Furthermore, the rise of universities in the first quarter of the 19th century drove a demand for more precise—and, to put it crudely, just *more*—copies of exemplars for technical and scientific research.[41] Finally, as two Soviet historians put it, "[t]he introduction of a unitary system of measures was important for the political and economic uniformity of Russia in connection with the expansion of territory. But to introduce it, it was necessary to have a system of measures that would dominate, because of its quality, the systems that were employed earlier."[42] There were two options for precision—the British and the metric—and the latter was politically unacceptable to Nicholas.

These economic and social reasons were compounded by the rapid introduction of the railroad into Russia in 1835—the same year that measures were standardized. Although there were some small railways in Russia before the 1830s, these were mostly localized at mines. There had been some interest since the 1810s in applying Western industrial inventions to improve transportation in Russia, such as an attempt to get Robert Fulton to import his steamboat to navigate the Russian river network (he died before the terms of his contract were completed). On 24 March 1833, Nicholas enacted a law for

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[39] RGIA f. 28, op. 1, d. 32.

[40] RGIA f. 28, op. 1, d. 54.

[41] Kamentseva and Ustiugov, *Russkaia metrologiia*, 193 and 218. These pressures were further exacerbated by the increase in technical education under Nicholas I. See Walter M. Pintner, *Russian Economic Policy under Nicholas I* (Ithaca, NY: Cornell University Press, 1967), 44–55.

[42] Kamentseva and Ustiugov, *Russkaia metrologiia*, 218.

the reconstruction of the major roads in Russia.[43] Yet it was only on 6 January 1835, in response to a suggestion from the Austrian Franz Anton von Gerstern, that consideration of state sponsorship of railroads began to be taken seriously. Also in January 1835, the Directorate of Ways and Communications and Public Buildings set up a commission on railway construction.[44] Eventually the decision was taken to build the Tsarskoe Selo line, constructed from 1 May 1836 to October 1837. During these early deliberations, several metrological decisions were undertaken, such as the establishment of the famous wide Russian gauge.[45] Metrology was crucial for the gauge. Errors of a few inches would cause trains to derail and engines not to work. It was not enough to rely on local measures of the *sazhen* and *arshin* while building a line; one had to restandardize the units, distribute new exemplars monitored by a central agency, and only then begin construction.[46] There existed, then, a cycle of standardization: metrological standardization had to come with the railroads, which in turn were supposed to standardize (in the more general sense) aspects of imperial economic policy, like communication and grain shipments. This cycle seems to be a constant factor in every metrological reform; the specific *character* of the reforms, however, always bore the stamp of fluctuations in contemporary Russian notions of governance.

The pattern of general standardization in Nicholas's Russia extended into the bureaucratic realm, including one of Nicholas's most noted reforms, the codification of the laws. Codification, like standardization, was something that every tsar since Peter I had tried—and failed—to accomplish, the most famous

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[43] Richard Mowbray Haywood, *The Beginnings of Railway Development in Russia in the Reign of Nicholas I, 1835–1842* (Durham: Duke University Press, 1969), 24 and 52; Viktor Semenovich Virginskii, *Vozniknovenie zheleznykh dorog v Rossii do nachala 40-kh godov XIX veka* (Moscow: Gos. transportnoe zheleznodorozhnoe izd., 1949).

[44] On the early chronology of railway development in Russia, see J. N. Westwood, *A History of Russian Railways* (London: Allen and Unwin, 1964), 22; Haywood, *The Beginnings of Railway Development in Russia*, 65; Virginskii, *Vozniknovenie zheleznykh dorog v Rossii*; Pintner, *Russian Economic Policy under Nicholas I*, 133–42; and Viktor Semenovich Virginskii, "Zheleznodorozhnyi vopros v Rossii do 1835 goda," *Istoricheskie zapiski* 25 (1948): 135–68. For an invaluable collection of primary sources on the debate concerning the early railroads, see M. Krutikov, "Pervye zheleznye dorogi v Rossii," *Krasnyi arkhiv* 76 (1936): 83–155. On railroad development after this period, see Richard Mowbray Haywood, *Russia Enters the Railway Age, 1842–1855* (Boulder, CO: East European Monographs, 1998); S. A. Urodkov, *Peterburgo-Moskovskaia zheleznaia doroga: Istoriia stroitel'stva (1842–1851 gg.)* (Leningrad: Izd. LGU, 1951); and Alfred J. Rieber, "The Formation of La Grande Société des Chemins de Fer Russes," *Jahrbücher für Geschichte Osteuropas* 21 (1973): 375–91.

[45] On the gauge, see Westwood, *A History of Russian Railways*, 30–31, 62.

[46] Pintner, *Russian Economic Policy under Nicholas I*, 131.

attempt being Catherine II's Legislative Commission.[47] As the story of Nicholas's codification is often told, after the Decembrist Revolt of 1825 that greeted his accession to the throne, he became convinced that rational codification of the laws was something that could no longer wait, and so he brought Mikhail Mikhailovich Speranskii—Alexander I's fallen favorite—in from administrative exile in Siberia to resume the task he had begun more than ten years previously.[48] First, Speranskii and his employees searched various local archives and gathered together the codes from all the localities. Contradictions were eliminated and repealed laws discarded. For the most part, local laws were ignored, with the partial exception of the Baltic region, which was allowed to maintain legal autonomy after codification.[49] Instead of systematizing the code to be derived from rational principles (Speranskii's preferred choice), the completed assembly of the laws was formally declared the law of the empire as it stood (Nicholas's preference).[50]

The formal similarities between codification and metrology are striking. Both began at the same time, both started with a collection of prototypes from all corners of the empire, and both ended up selecting a particular set as the uniform standard. The idea of the metrological reform was to eliminate the inadequacies of the former disparate laws, legalize a certain set of measurements, and not try to determine whether there should be a rational correlation between measures. In other words, neither the metric system nor the Napoleonic code was considered. The rhetoric used by Speranskii in the codification literature points to this deep similarity in philosophy.[51] An intense push for centralization was also exhibited in the metrological laws: all control over standards, from verification to storage to enforcement, was to be directed from the center. It seems that in the case of measures, as long as the central government had control, it made little difference that this control was divided and uncoordinated between the MVD and the MF. The ideology of

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[47] Richard S. Wortman, *The Development of a Russian Legal Consciousness* (Chicago: University of Chicago Press, 1976), 16.

[48] Marc Raeff, *Michael Speransky: Statesman of Imperial Russia, 1772–1839*, 2nd ed. (The Hague: Martinus Nijhoff, 1969), 320. See also William Benton Whisenhunt, *In Search of Legality: Mikhail M. Speranskii and the Codification of Russian Law* (Boulder, CO: East European Monographs, 2001), chap. 3.

[49] Raeff, *Michael Speransky*, 339–40.

[50] Mikhail Mikhailevich Speranski, *Précis des notions historiques sur la formation du corps des lois russes* (St. Petersburg: Mme. Pluchart et fils, 1833), 67 and 177–78.

[51] Speranski, *Précis des notions historiques*, 53. See also Aleksandr Emil′evich Nol′de, *Ocherki po istorii kodifikatsii mestnykh grazhdanskikh zakonov pri Grafe Speranskom* (St. Petersburg: Senatskaia tip., 1906), i, 3, 9, and 15. See also Raeff, *Michael Speransky*, 344.

codification was an attempt to introduce a system into the ministerial structures set up by the regime of Alexander I.[52]

Institutionalizing Metrology: The Mendeleev Years

The history of the standardization of weights and measures, culminating in the introduction of the metric system into Russia for optional use in 1899 and then completely in 1918, is intimately bound with the work of D. I. Mendeleev as director of the Chief Bureau of Weights and Measures, created out of the Depot in 1893 upon his appointment.[53] Having resigned from St. Petersburg University in April 1890 in the wake of student unrest, Mendeleev sought employment from the Navy Ministry, helping to develop a new form of smokeless gunpowder.[54] The offer from his friend and ally on economic matters, Sergei Iul′evich Witte, to assume the metrological position, however, soon persuaded him away from his naval work and he devoted the remaining 14 years of his life to problems of standardization. Mendeleev did not begin his work as director of the Chief Bureau of Weights and Measures by embarking immediately on the introduction of the metric system. He began by reforming institutions.

The GPMV replaced the earlier Depot of Exemplary Weights and Measures in 1893, and the post of director replaced that of learned storekeeper. In a sense, Mendeleev was given a chance to fulfill a lifelong dream: creating an institution in his own image, and generating on a small scale his own vision of an ordered Russia. The Depot had not been such an

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[52] Wortman, *Development of a Russian Legal Consciousness*, 4, 43; Raeff, *Well-Ordered Police State*, 38; and Richard G. Robbins, Jr., *The Tsar's Viceroys: Russian Provincial Governors in the Last Years of the Empire* (Ithaca, NY: Cornell University Press, 1987), 12. The development of the postal service in this period also bears strong similarities to the standardization reform. See K. Basilevich, *Pochta v Rossii v XIX veke* (Moscow: Sviaz′, 1927).

[53] The secondary literature on Mendeleev's metrology is vast. For some of the better sources, see Mikhail Nikolaevich Mladentsev, "Uchrezhdenie Glavnoi Palaty mer i vesov i eia deiatel′nost′"; *D. I. Mendeleev: Ego nauchnoe tvorchestvo i raboty v Glavnoi Palate mer i vesov* (Moscow: Tsentral′noe upravlenie prompropagandy i pechati VSNKh SSSR, 1926); Nikolai G. Egorov, "Dmitrii Ivanovich Mendeleev (nekrolog)," *VGPMV* 8 (1907): 3–18; Nikolai Aleksandrovich Shost′in, *D. I. Mendeleev i problemy izmereniia* (Moscow: Komitet po delam mer i izmeritel′nykh priborov pri Sovete ministrov SSSR, 1947); Valentin Zakharovich Azernikov and N. F. Vasil′kova, comps., *Mendeleev—metrolog* (Moscow: Izd. standartov, 1969); Valerii Vasil′evich Boitsov, ed., *D. I. Mendeleev—osnovopolozhnik sovremennoi metrologii* (Moscow: Izd. standartov, 1978); D. I. Mendeleev, *Trudy po metrologii* (Leningrad: Standardtgiz, 1936); and Nathan M. Brooks, "Mendeleev and Metrology," *Ambix* 45 (1998): 116–28.

[54] On this, see my "A Modernization of 'Peerless Homogeneity': The Creation of Russian Smokeless Gunpowder," *Technology and Culture*, forthcoming.

ordered institution. Originally located in the Peter and Paul Fortress next to the Mint, its second and final storekeeper, V. S. Glukhov, in his only substantial success, moved it to specially constructed quarters on Zabalkanskii Prospect (now Moskovskii Prospect), across from the St. Petersburg Technological Institute.[55] Glukhov has often been considered inconsequential compared to his illustrious precursor and successor. Glukhov, however, was a highly respected metrologist often cited for his thermometry, and he worked to preserve the historical measures of Muscovite and imperial Russia, a task that Mendeleev would later essentially abandon.[56] Glukhov also produced substantial plans for the eventual introduction of the metric system into Russia. He wrote in an official report as early as 1876: "[Russia] alone now hinders these [metric] measures from becoming pan-European and thus completing the many years of work of the international association for the universal introduction of identical weights and measures."[57] As becomes clear on inspecting the budgets of the Depot, Glukhov had great difficulty obtaining resources in the complicated personality politics of official Petersburg, so he had to remain content with idly drawing up elaborate plans. These plans bear an uncanny similarity to the program Mendeleev would propose and implement, and I argue that Mendeleev to a considerable degree silently followed Glukhov's blueprint.[58]

Electrification was a major technological impetus for the 1899 renovation of standards and especially for the allowance of the metric system. Electrical devices, unlike trains, were made and calibrated exclusively in metric units,

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[55] The Ministry of Finance's proposal for the transformation of the older facility is "O preobrazovanii Depo obraztsovykh mer i vesov," 26 April 1893, ADIM Bib. 1044/78.

[56] Mendeleev cited Glukhov's thermometry in his 1865 doctoral dissertation: *MS*, vol. 4, 39. In the first issue of the *VGPMV*, Glukhov published his last article, which happened to be on historical metrology: V. Glukhov, "Izmereniia, otnosiashchiiasia k sravneniiu zheleznoi sazheni 'Kommissii 1833 goda' s raznymi merami dliny, proizvedennye v 1884 godu V. S. Glukhovym i F. P. Zavadskim," *VGPMV* 1 (1894): 1–56. Early in his tenure, Mendeleev did write to Kovalevskii on 18 November 1893 that he wanted to move historically interesting measures from the Mint to the Bureau, but such correspondence ceased shortly afterward. RGIA f. 28, op. 1, d. 186, ll. 1–1ob.

[57] Glukhov, "O dozvolitel′nom vvedenii v Rossiiu metricheskikh mer," RGIA f. 28, op. 1, d. 117, ll. 1–4, on l. 2.

[58] See especially V. S. Glukhov, *Doklad vysochaishe uchrezdennoi kommissii dlia preobrazovaniia Depo obraztsovykh mer i vesov*, 1 October 1875 (St. Petersburg: Tip. Akademii nauk, 1875), RGIA f. 28, op. 1, d. 113, ll. 9–58. See also RGIA f. 28, op. 1, d. 108 (budgets from 1874–82); RGIA f. 28, op. 1, d. 167, ll. 1–7 (28 December 1889 report on status of the Depot); RGIA f. 28, op. 1, d. 167, ll. 19–26 (proposal for a metrological reform [1889]). Mendeleev acknowledged some of Glukhov's preparatory work in a letter to Kovalevskii, 21 December 1892, *MS*, vol. 22, 33.

which meant that if Russia had no reliable prototype voltmeters or ammeters, electrification would not be able to proceed. Russian interest in standardizing electrical units went back to 1846, when the Russian electrochemist B. S. Jacobi proposed distributing standard lengths of copper wire so that resistances could be calibrated.[59] (The plan turned out to be untenable because copper does not keep a standard resistance.) Electric trams desperately needed standardization: Moscow and Petersburg were working with different parameters, all necessitating two separate electrical industries. The electric telegraph was also used to increase communication across the empire, and the failure of the first Atlantic cable due to English neglect of standardized units of resistance demonstrated the importance of metrology.[60] A letter written in 1859 to the Petersburg Academy of Sciences stated: "It is difficult to believe that an epoch in which mankind is connected by railroads and the electric telegraph is not able also to bring about the introduction of uniform weights and measures."[61] Mendeleev undertook serious efforts to standardize electrical units in Russia. In this case, there was substantial unanimity from the Russian Technical Society, the Academy of Sciences, and the GPMV that the metric units (ohm, volt, ampere) should be adopted, and Mendeleev—just as Glukhov had a decade earlier—pressed for adherence to international metric electrical protocols. Likewise, he established a long overdue electrical laboratory at the GPMV.[62]

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[59] Hallock and Wade, *Outlines of the Evolution of Weights and Measures and the Metric System*, 205.

[60] On this complicated process, see, especially, Schaffer, "A Manufactory of Ohms"; and Crosbie Smith and M. Norton Wise, *Energy and Empire: A Biographical Study of Lord Kelvin* (Cambridge: Cambridge University Press, 1988).

[61] Quoted in Moisei Izrailevich Radovskii, "K uchastiiu russkikh uchenykh v mezhdunarodnykh soglasheniiakh o edinstve mer i vesov," *Istoricheskii arkhiv*, no. 2 (1958): 120–33, on 122. On standardization in the Russian electrical industry, see Jonathan Coopersmith, *The Electrification of Russia, 1880–1926* (Ithaca, NY: Cornell University Press, 1992), 55, 60; and Kamentseva and Ustiugov, *Russkaia metrologiia*, 236.

[62] On international standards for electromagnetic units, see Mendeleev to Vladimir Ivanovich Kovalevskii, 8 January 1895, *MS*, vol. 22, 750–51; Mendeleev to Kovalevskii, 16 March 1894, *MS*, vol. 25, 538; Mendeleev to Department of Trade and Manufactures, 23 October 1893, RGIA f. 28, op. 1, d. 184, ll. 2–2ob.; and Glukhov to the Department, 23 April 1886, RGIA f. 28, op. 1, d. 149, ll. 2–2ob. On regulations for electrical measurement in Russia, see N. Egorov, "O pravitel′stvennoi vyverke elektricheskikh izmeritel′nykh priborov v zapadno-evropeiskikh gosudarstvakh," *VGPMV* 4 (1899): 81–121; and "Vremennyia pravila dlia ispytaniia i poverki elektricheskikh izmeritel′nykh priborov, predstavliaemykh v Glavnuiu Palatu mer i vesov," *VGPMV* 6 (1903): 109–13. On the electrical laboratory, see I. Lebedev, "Elektricheskoe otdelenie Glavnoi Palaty mer i vesov," *VGPMV* 7 (1905): 1–22.

In addition to technological pressures, a series of international agreements pushed the Russian government to shift to the metric system. On 20 May 1875 (N.S.), Russia signed an agreement with the International Metric Committee in Paris to the effect that it would try to convert to the metric system, a treaty also signed by Germany, Austria-Hungary, Belgium, Brazil, the United States, Argentina, Denmark, Spain, France, Italy, Peru, Portugal, Sweden and Norway, Switzerland, Turkey, and Venezuela.[63] Failure by Russia to comply with the terms of this agreement would have damaged its standing in Europe and hurt its image as a "civilized state of commercial importance."[64] The terms of this treaty were established at the first meeting of the Metric Committee on 8 August 1870 (N.S.), but the ongoing Franco-Prussian war mitigated chances for pan-European success. Tensions were eased by 1875, and after renewed metric prototypes were created, Russia took home its own prototype kilogram (#12) and meter (#28) from Paris in 1889.[65]

It would be a mistake, however, to attribute influence to this treaty without recognizing the forces that caused it to emerge in the first place: the movement led by international scientists to universalize weights, measures, and currency.[66] The original impetus for this movement began not in France, but in Russia, spearheaded by Kupfer and Jacobi. In 1855–65, Kupfer was an active member of the International Society for the Establishment of a Unitary System of Measures, Weights, and Moneys.[67] On 3 June 1867, Jacobi, as president of the Imperial Academy of Sciences in Petersburg, sent a communiqué to the Paris Academy suggesting that scientists undertake the task of convincing their nations to join in metrological uniformity:[68]

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[63] Zupko, *Revolution in Measurement*, 230.

[64] Quotation from George Eastburn, *The Metric System* (New York: American Metrological Society, 1892), 17.

[65] Kamentseva and Ustiugov, *Russkaia metrologiia*, 229–32. For the history of these international committees, see Charles-Edouard Guillaume, *La convention du mètre et le Bureau international des poids et mesures* (Paris: Gauthier-Villars, 1902).

[66] There were, however, of course also bureaucratic requests to accelerate the introduction of the metric system for the sake of international trade. Mendeleev to V. I. Mikhnevich, 19 March 1894, RGIA f. 28, op. 1, d. 195, ll. 2–3ob.; and Mendeleev to V. M. Verkhovskii, 20 February 1898, RGIA f. 28, op. 1, d. 220, ll. 2–3ob.

[67] Kamentseva and Ustiugov, *Russkaia metrologiia*, 226. For a brief history of these events, see Radovskii, "K uchastiiu russkikh uchenykh v mezhdunarodnykh soglasheniiakh o edinstve mer i vesov," 120–21.

[68] "Comme toute économie de travail, tant matérial qu'intellectual, équivant à une véritable augmentation de richesse, l'adoption du système métrique, qui se range dans le même ordre d'idées que les machines et les outiles, les voies ferrées, les télégraphes, les tables logarithmiques,

> The introduction into Russia of French weights and measures would be a big boon not only for Russia but also for Europe. The French metric system best answers all the demands of science, industry, and trade: the first [science] by its strictness and logic; industry by its simplicity; trade by the fact that it is employed in many other states of Europe. If Russia and England adopted the metric system, then it would be possible to say that all of Europe had one and the same weights and measures.[69]

In 1869, the Petersburg Academy again sent a request to France to begin the process of internationalizing the system of measurement, and on 8 August 1870 (N.S.), after an initially hostile reception by French scientists who did not want other nations meddling in French units, a Parisian commission was set up to establish reliable units for the meter and kilogram. Throughout this period, the scientists involved presented themselves as transnational agents, facilitating the process of establishing a "common language" for modern Europe, even presenting their meteorological findings in terms of the metric system as an example.[70] Early in 1867, the Russian Technical Society and the Industrial Conference began agitating for the benefits of the metric system; and in 1870, the Industrial Conference called for the introduction of the metric system in the postal-telegraphic service and the railroads. In 1872, a pavilion in the Moscow Polytechnic Institute was built to educate the public about the system, bearing fruit in terms of overwhelming supporting according to an 1896 MF poll of industrialists.[71]

Mendeleev was part of this international movement and a logical choice for the post of director of the GPMV.[72] In his first statement on the metric system on 28 December 1867, Mendeleev argued for it as a means of international scientific unification, one that was easy to work with because of the decimal system, which with its exact exemplars standardized electrical and mechanical international systems (like the railroad) and were "best suited to

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se recommande particulièrement, sous le point de vue économique." Quoted in Guillaume Bigourdan, *Le système métrique des poids et mesures* (Paris: Gauthier-Villars, 1901), 250.

[69] Quoted in Radovskii, "K uchastiiu russkikh uchenykh v mezhdunarodnykh soglasheniiakh o edinstve mer i vesov," 126.

[70] Jacobi, "Note sur la confection des étalons prototypes, destinés à généraliser le système métrique," *Comptes rendus* 69 (1869): 854–57, on 854. For the reaction to Jacobi's proposal, see "Mémoires et communications des membres et des correspondants de l'Académie," *Comptes rendus* 69 (1869): 425–28.

[71] *Metricheskaia reforma v SSSR* (Moscow: Tsentral′naia metricheskaia komissiia, 1928), 8–9.

[72] The Mendeleev hire was approved directly by Minister of Finance Sergei Iul′evich Witte. See Witte's authorization to the Department of Trade and Manufactures, 1 May 1893, RGIA f. 40, op. 1, d. 1, ll. 66–66ob.

universal distribution." As a result of "uniformity in all relations," the metric system was able—together with printing, trade, and science—to prepare for "the unification of all nations … the dream of the world."[73] Mendeleev pointed out that a host of nations, including almost all the European powers, had either converted to optional use of the metric system or were about to, and he urged scientists and teachers to employ the metric system so as to accustom the public to it gradually, as he did in his own famous textbook, *Principles of Chemistry*.[74]

Mendeleev practiced what he preached by becoming active in metrological projects. Since 1863, Mendeleev had been heavily involved in the MF's attempts to reform the state's liquor monopoly through the recalibration of Russian volume and weight measures to metric ones. Extrapolating from his doctoral research on alcohol-water solutions, Mendeleev urged better alcoholometry to improve excise tax collection and preserve uniform quality in vodka production.[75] This has been famously misinterpreted as Mendeleev "creating" the 80-proof vodka standard, a view that has recently been compellingly dismissed with the recognition that the 40%-by-volume metric had been standard long before Mendeleev.[76] Mendeleev had been appointed to succeed Jacobi on the International Metric Commission as early as the mid-

[73] *MS*, vol. 22, 25–26. Interestingly, almost all of the domestic advocates of the metric system in Russia were chemists like Mendeleev. This was a more general phenomenon, as noted in another context: "To engineers such relations [of length to mass and specific gravity] are of small moment, and consequently among English-speaking engineers the metric system is making no progress, while, on the other hand, the chemists have eagerly adopted it." William Harkness, *On the Progress of Science as Exemplified in the Art of Weighing and Measuring* (Washington: Judd and Detweiler, 1888), 64–65.

[74] *MS*, vol. 13, 16 n. 2, 18–20.

[75] Mendeleev's first venture into this field was an entry in a contest to measure alcohol content. Mendeleev and E. Radlov, 30 July 1863, RGIA f. 18, op. 8, d. 253. Mendeleev's 1864 doctoral dissertation is reproduced in *MS*, vol. 4, 1–152. For a survey of alcoholometry and Mendeleev's involvement in the reform of the vodka farm, see Liudmilla Borisovna Bondarenko, "Iz istorii russkoi spirtometrii," *Voprosy istorii estestvoznaniia i tekhniki*, no. 2 (1999): 184–204; Sergei Zakharovich Ivanov, "D. I. Mendeleev—sozdatel′ nauchnykh osnov sovremennoi spirtometrii," *Trudy Leningradskogo tekhnologicheskogo instituta pishchevoi promyshlennosti* 12 (1955): 195–207; and David Christian, *"Living Water": Vodka and Russian Society on the Eve of Emancipation* (Oxford: Clarendon Press, 1990), 364.

[76] For the legend of Mendeleev's "creation" of the 80-proof standard, see Vil′iam Pokhlebkin, "Mendeleev i vodka," *Ogonek*, no. 50 (December 1997): 4–5. His view is effectively refuted by Igor′ Sergeevich Dmitriev, "Natsional′naia legenda: Byl li D. I. Mendeleev sozdatelem russkoi 'monopol′noi' vodki?" *Voprosy istorii estestvoznaniia i tekhniki*, no. 2 (1999): 177–83.

1870s and was an active member until domestic metrological work drew him away in the 1890s.[77]

The 1899 Law: Precision Metrology

These domestic efforts centered around Mendeleev's major historical accomplishment at the bureau: the law that led to the optional introduction of the metric system into the empire, decreed on 4 June 1899 and in effect as of 1 January 1900.[78] The law focused intensely on precision measurement. Not only were all the standards to be made of a 90%-platinum/10%-iridium alloy—the temperature-invariant international standard—but this law was the first to treat time as a unit to be codified and sanctioned by the state. The reform represented a highly articulated elaboration of the framework that Glukhov had laid out, the capstone of a series of stages all designed to bring about the total conversion of Russia to the metric system.

Mendeleev firmly believed the introduction of the system in Russia was inevitable. The nature of his job, he felt, was to make sure that it happened smoothly and that the system actually functioned throughout the vast empire.[79] The central conveniences of the system were the primary reasons for its inevitability—decimal accounting, for example—but Mendeleev was aware that those conveniences could be incorporated into any system of measurement—a decimal breakdown of the *sazhen* or *funt*, for example.[80] What made it inevitable had nothing to do with the metric system per se or with its relationship to nature. It was inevitable because of man-made, arbitrary conventions, such as Russia's adherence to international agreements, or the fact that other nations were converting and it was convenient for trade. It is important to understand that the appeal of Mendeleev's metric reform

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[77] Mendeleev was proposed for nomination by Auguste Tresca of the French Conservatoire, and the two kept in close touch about metrology for several decades. "Zapisnaia knizhka, 1874–1876," no. 20, ADIM II-A-1-1-9, entry of 20 June 1874, l. 12; and Mendeleev to Tresca, 5 May 1894, ADIM I-A-25-1-11. For a meticulous chronicle of Mendeleev's work on the metric commission, see Ol′ga Pavlovna Kamenogradskaia, ed., *Deiatel'nost′ D. I. Mendeleeva v S.-Peterburgskom universitete i nauchnykh obshchestvakh. Uchastie v rabote mezhdunarodnykh general'nykh konferentsii po meram i vesam i mezhdunarodnogo komiteta mer i vesov v Parizhe* (Leningrad: BAN, 1985), 148–56.

[78] *PSZ* 3, vol. 19, 17056.

[79] These inevitability statements are quite frequent; see, for example, *MS*, vol. 22, 26; and vol. 25, 560. On the use of decimal accounting in other systems, see vol. 22, 325.

[80] For an example of attempted decimalization of the *sazhen*, see Fedor Fomich Petrushevskii, "Russkaia desiatichnaia sistema mer," *Zhurnal Russkogo fiziko-khimicheskogo obshchestva* 25, otd. 2 (1893): 91–93.

had nothing *natural* about it; it was precisely the *artificial* (in the sense of constructed) reasons for its adoption that Mendeleev found most persuasive.

Mendeleev's metric reform, then, was not about making Russia's measurement conventions adhere to a natural standard but about making those conventions adhere to a different set of conventions. Hence in the first stage of the reform the standard exemplars of weights and measures needed to be recalibrated. Russia needed new prototypes not only for Russian units but for metric and British units as well. In 1892, before he officially became director, Mendeleev informed his superior, Minister of Finance Vladimir Ivanovich Kovalevskii, of "the necessity of renewing them [the Russian prototypes], since all means that touch on the unification of weights and measures in the empire must, by their very essence, depend on the maintenance of prototypes."[81] Russia's need for recalibration was created by wear and tear on the old standards, last renewed in 1835, but also by European events. In 1834, a fire in England had destroyed the old exemplars, so the British had to create new prototypes, which since 1852 had been recalibrated every ten years. Most European nations followed suit. In fact, the example of several nations showed that any prototypes forged earlier than 1850 would have to be renewed.[82] The Russian platinum-iridium prototypes were requisitioned from the London firm of Johnson, Matthey, and Co. in 1893 and received in 1898.[83] The reform's next stage was the correlation of Russian prototypes with exact metric equivalents, whereas earlier, given the exact relation of the British weights to the Russian standards, it was simply more convenient to generate conversion tables between them.[84]

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[81] Mendeleev to Kovalevskii, 21 December 1892, *MS*, vol. 22, 29.

[82] *MS*, vol. 22, 30 and 47.

[83] Matthey sent Mendeleev a telegram confirming his instructions on the renewal on 10 January 1894, ADIM I-V-42-1-11. On the difficulties of producing reliable standards, see George Matthey, "The Preparation in a State of Purity of the Group of Metals Known as the Platinum Series, and Notes upon the Manufacture of Iridio-Platinum," *Chemical News* 39 (1879): 175–77. On the course of renewal work, see Mendeleev to Kovalevskii, 30 October 1893, *MS*, vol. 22, 727–30; "The course of the work on the renewal of prototypes, or exemplary measures of length and weight (21 June 1895)," *MS*, vol. 22, 175–213; Mendeleev to Witte [1895?], *MS*, vol. 22, 752; and the final report sent to Witte, "Vozobnovlenie prototipov ili osnovnykh obraztsov russkikh mer vesa i dliny v 1893–1898 gg. (1898)," *MS*, vol. 22, 393–721.

[84] *MS*, vol. 22, 44, 731, 746; and vol. 25, 552. The requisite weighing procedures were minutely outlined by Mendeleev in vol. 22, 215–23. The final table of conversions, also sent to the International Metric Commission in Paris, is reproduced in vol. 22, 763–69.

The third stage was the most important for Mendeleev: the establishment of local verification stations (bureaus) dispersed across the empire.[85] Russian officials had long lamented the lack of a system of verification for weights and measures. The 1835 standardization law had distributed exemplary weights to major centers of trade and industry, but no mechanism required individuals to have their weights verified; and even where some rudimentary ad hoc process was enforced, the exemplars had so deteriorated as to make any verification counterproductive. Some localities were still using weights from the 1830s, and even the Mint and the State Bank had inadequate prototypes (Mendeleev had to renew them as his first act).[86] The problem now was to establish some procedure by which localities could be calibrated with the center.

A major distinction between Glukhov's and Mendeleev's approaches was that Glukhov preferred importing a Western protocol for local verification, while Mendeleev wanted to adapt a Western system to local Russian circumstances.[87] The first few issues of the GPMV's journal contained reports from a series of inspection trips by Mendeleev's assistants to various parts of European and Siberian Russia, as well as Western Europe, to report on the various mechanisms (or lack thereof) for verification of weights and measures.[88] The domestic disorder was extraordinary. In all these places, the

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[85] Throughout, I have translated the word *palatka* as bureau (lower case), to show the symmetry between these smaller units and the Chief Bureau (*Palata*) in Petersburg.

[86] Glukhov to Department of Trade and Manufactures, 22 March 1886, RGIA f. 28, op. 1, d. 148, ll. 1–2ob.

[87] The foreign model Mendeleev most closely approximated was the German Physikalisch-Technische Reichsanstalt. On this institution, see David Cahan, *An Institute for an Empire: The Physikalisch-Technische Reichsanstalt, 1871–1918* (Cambridge: Cambridge University Press, 1989).

[88] The cities and regions visited were: Nizhnii Novgorod, Kazan′, Saratov, Riazan′, Moscow, Orel, Kursk, Tomsk, Krasnoiarsk, Irkutsk, St. Petersburg (both port and land customs houses), Verzhbolovskii, Volochiskii, Odessa, Warsaw, Grantskii, Riga, Lodz′, Lublin, Tver′, Maloiaroslavets, Kaluga, Tula, Vladimir, Kostroma, Iaroslavl′, Rybinsk, Syzran′, Penza, Samara, Ufa, Zlatoust′, Cheliabinsk, Ekaterinburg, Perm, Irbit, Smolensk, Chernigov, Kiev, Berlin, Munich, Vienna, and Paris. The reports were published as: S. I. Lamanskii, "Iz otcheta, predstavlennago i. o. inspektora Glavnoi Palaty mer i vesov S. I. Lamanskii," *VGPMV* 3 (1896): 119–24; Fedor Ivanovich Blumbakh, "Dannyia o vyverke mer i vesov v Sibiri; iz otcheta, predstavlennago poveritelem G. Palaty F. I. Blumbakhom," *VGPMV* 3 (1896): 124–32; A. Skinder and S. Lamanskii, "Materialy dlia sostavleniia instruktsii o vyverke torgovykh mer i vesov," *VGPMV* 1 (1894): 102–23; A. Dobrokhotov, "Otchet o komandirovke v Tver′, Moskvu, Maloiaroslavets, Kalugu, Tulu, Vladimir, Nizhnii-Novgorod, Kostromu, Iaroslavl′ i Rybinsk," *VGPMV* 6 (1903): 1–24; K. Egorov, "Otchet po komandirovke v goroda Varshavu, Lodz′ i Liublin," *VGPMV* 5 (1900): 74–144; idem, "Otchet o komandirovke v goroda: Riazan′, Syzran′, Penzu, Samaru, Ufu, Zlatoust′, Cheliabinsk, Ekaterinburg, Perm′ i Irbit," *VGPMV* 6 (1903): 46–83;

inspector would first make sure exemplars existed, and then go with the police to stores to determine what was used in trade. In Russia proper *only* Moscow and Petersburg had special places where stamping and verification of measures could take place, and the Petersburg one was handicapped by ancient exemplars. The only well-functioning system in the entire empire was Riga's. Reform of the verification structure was necessary before any thought of the metric system could be entertained: "The immediate introduction of the metric system [the director of the Treasury bureau in Irkutsk] considers unthinkable, if one wants to have any kind of order."[89] At least now locals knew what the current measures were—more or less—and to introduce a new system, you had to first instill trust that the new system was at least as fair as the old one. Mendeleev concurred: "[A] wider application of the metric system cannot be considered until local verification establishments are built and well organized."[90]

Russia was a vast empire, so if there were accurate metrological standards in Petersburg (in one faraway corner), that would do nothing for standardization, let alone getting the metric standards distributed to all localities. The answer was to divide the country into metrological zones, each with its own verification bureau and team of "verifiers." These individuals were to inspect the trade and industrial measures in each region, enforce local standards, and thus serve as a way of correlating and standardizing the empire.[91] The GPMV took persons and standardized them to function as verifiers; these were then sent all over the empire to follow the prototypes. The GPMV's power was constituted by the widespread distribution of the local bureaus—the more decentralized power nodes there were, and the more they dispersed, the stronger the GPMV became through the wider scope of its authority. The GPMV worked beyond its localized site in St. Petersburg only to the extent that it invested each local bureau with part of its authority; these local bureaus returned the favor by making the authority of the Bureau more solid. No wonder Mendeleev wanted to expand the number of local verifiers until the day "when the entire empire is *covered by a net* of local bureaus."[92]

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and idem, "Otchet o komandirovke v goroda: Smolensk, Chernigov i Kiev," *VGPMV* 6 (1903): 99–108.

[89] Blumbakh, "Dannyia o vyverke mer i vesov v Sibiri," 129.

[90] Mendeleev to Verkhovskii, 20 February 1898, RGIA f. 28, op. 1, d. 220, ll. 2ob.–3.

[91] For a few of the statements on the importance of these local bureaus for the metric reform, see *MS*, vol. 22, 327, 328, 800, and 838. Its relation to the renewal of prototypes is described in a letter to V. M. Verkhovskii on 20 February 1898, in *MS*, vol. 22, 770.

[92] *MS*, vol. 22, 794. Emphasis added. Mendeleev's assistants also used this rhetoric, at one point claiming that "such control is possible only upon the existence of an entire net of special local

Just what was meant by this "net" was complicated in practice. There was significant debate about whether to place them in local technical societies, railroad administration offices, or educational institutions.[93] Mendeleev opposed using city councils or chambers of commerce, since they were staffed by the proprietors of the large shops who had the most to gain from inaccurate measures. Instead, he proposed relying on individuals with scientific training, who would be "entirely of good conscience and independent." The hope, he argued, was "for Russia to decentralize a bit, at least in these matters." After considering using the local rural councils (*zemstva*), Mendeleev opted instead for creating a system within the GPMV's administrative network.[94] The number of intended bureaus was correspondingly large: given the 90 districts and zones in Russia, Mendeleev projected a need for at least 100 fully stocked verification bureaus. An additional 50 smaller ones were to be partially equipped (with units of weight and length, but not electrical or more specialized measures) to accommodate areas of heavy trade where demand was excessive. Mendeleev did not want to rush construction. Given the lag in recouping costs, no more than 15 bureaus should be constructed in a year.[95] Neither the pace of construction nor the final goal of 100–150 bureaus was met.

The bureaus were not just meant to standardize measures. They were also supposed to standardize people: both the verifiers and the verified. First, the system of regulations was standardized by conferring all control over the local bureaus, originally split under a heterogeneity of jurisdictions, including those of the MF and the GPMV (itself under the Ministry of Trade), to the GPMV exclusively.[96] The inspectors were to be standardized by training them in

verification establishments." Egorov, "Otchet po komandirovke v goroda Varshavu, Lodz′ i Liublin," 74.

[93] In favor of using status quo institutions was the director of the Moscow Assaying District to the Department of Trade and Manufactures, 11 April 1899, RGIA f. 28, op. 1, d. 482, ll. 3–4ob.

[94] Mendeleev in Ministerstvo Finansov, Departament Torgovli i Manufaktur, *Zhurnaly zasedanii kommissii po peresmotru deistvuiushchikh o merakh i vesakh uzakonenii* (St. Petersburg: V. Kirshbaum, 1897), ADIM Bib. 1034/6, ll. 10, 17, and 22.

[95] *MS*, vol. 22, 792–97.

[96] *MS*, vol. 22, 792, 795, 847. For the actual regulations on stamping and verification, see "Vremennaia (1898 g.) instruktsiia No. 1 sostavlennaia Glavnoiu Palatoiu mer i vesov, dlia rukovodstva pri primenenii obraztsovykh mer i vesov v mestnykh poverochnykh uchrezhdeniiakh," *VGPMV* 4 (1899): 46–49; and "Vremennaia (1898 g.) instruktsiia No. 2 sostavlennaia Glavnoiu Palatoiu mer i vesov, dlia rukovodstva pri poverke i kleimenii torgovykh mer i vesov v mestnykh poverochnykh uchrezhdeniiakh," *VGPMV* 4 (1899): 50–56.

Petersburg and then distributing them to all the corners of the empire.[97] These local verifiers were deposited (along with their standards) in the local bureaus. These bureaus were in turn equipped to foster coordination and to deal with remote or immobile equipment, with two reserve verifiers per bureau who could travel; and then mobile bureaus on train wagons would travel around the country and standardize equipment wherever the tracks led (only one such wagon bureau was actually built).[98] Not only did Mendeleev create the supply of verifiers, he also created the demand. Under the 1899 law, all local standards used by tradesmen and industries needed to be verified once every three years. In addition, Mendeleev had his assistants conduct surprise inspections of post offices and banks to keep institutions prepared between the triennial verifications.[99] Mendeleev even proposed moving to an annual check—so the verifiers would constantly circulate and standardize—and then the impost fees collected would make the system self-financing (and, potentially, these bureaus could collect other taxes as well). Furthermore, the bureaus could use the inspection certificates from annual checkups to gather data on economic activity and thus inform a more accurate industrial policy.[100]

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[97] They all had the same training protocols, the same notions of measurement, and, thanks to the renewal of prototypes, the "same" standards in hand that they could carry to their separate zones. See D. I. Mendeleev, "Programma dlia ispytaniia v znanii metrologicheskikh priemov dlia lits, zhelaiushchikh postupit′ poveriteliami v mestnyia poverochnyia palatki," *VGPMV* 5 (1900): 179–81. Women could even serve as competent verifiers, but only at a ratio of one woman for each five men, and no more than two women per bureau. See Mendeleev to Kovalevskii, 21 October 1902, *MS*, vol. 22, 825–26. Mendeleev wrote that this was purely for financial reasons, as women were cheaper to hire than men, and the quota was only to preserve morale. This clearly parts from the feminist appraisal of Mendeleev by one of his female employees at the Chief Bureau: Ol′ga Erastovna Ozarovskaia, *D. I. Mendeleev po vospominaniiam O. E. Ozarovskoi* (Moscow: Federatsiia, 1929). Mendeleev also felt that "persons of the female gender" should be hired because accuracy and tedious precision were characteristics very appropriate for women, and metrology did not require much intellectual input, just adherence to a protocol. This is especially interesting since in Prussia precision was gendered male and not neuter, because it was seen as something that required great patience and intellect. Olesko, "The Meaning of Precision," 126.

[98] On the need for reserve verifiers, see *MS*, vol. 22, 793, 838. Mendeleev explained that verifiers needed to move around more than the police and tax collectors and thus could perform some of their functions. On wagons, see *MS*, vol. 22, 839.

[99] N. Egorov and A. Dobrokhotov, "Reviziia vesov i gir′ v Gosudarstvennom Banke," *VGPMV* 5 (1900): 60–63; and K. Egorov, A. Dobrokhotov, and V. Müller, "Reviziia vesov i gir′ v Pochtamte i pochtovykh otdeleniiakh g. S. Peterburga," *VGPMV* 5 (1900): 63–73. Regulations for the conduct of these inspections were spelled out in "Instruktsiia dlia proizvodstva vnezapnykh revizii," *VGPMV* 7 (1905): 177–78.

[100] On the shortening of terms, see *MS*, vol. 22, 840; on self-sufficiency, *MS*, vol. 22, 837; and on statistics gathering, *MS*, vol. 22, 842, 847–48. The shortening of terms was not adopted.

Mendeleev considered the complete network of local establishments a necessary component of full introduction of the metric system, but only a few bureaus were required for the fourth and final stage of Mendeleev's metric reform: the optional adoption of the metric system. Mendeleev considered mandatory adoption of the reform, as opposed to an optional approach, counterproductive. Imposing the metric system, as had been done in France a hundred years earlier, would inspire popular hostility and invite failure. If verification establishments were distributed everywhere and if informal metric conventions were adopted, the people would be, so to speak, "metricized," and it would become second nature for them to adopt the system:

> I am of the opinion that to coerce popular habits, the popular will, the popular sense in this set of affairs is, so to speak, a sin. I am a great supporter of the metric system but an even greater supporter of the Russian people and their historically formed conditions. I would like, for my part, that the people themselves, gradually, having the legal right to use the metric system, spoke out in its favor. I know that a state branch could very easily order the usage of some kind of system by a circular. But the issue is how the people will relate to it. It's easy to give an order. Thus it was in France: an order was given that the metric system be introduced by some sort of still revolutionary government, and the people didn't use it, even after 30 years!
>
> Thus, being a supporter of the metric system and understanding its benefits, I would like that it be voluntarily disseminated in the Russian milieu, and I oppose its immediate and compulsory introduction, I stand for its optional use, and chiefly for the introduction of verification establishments so that cheating in weights and measures will diminish somewhat.[101]

As he wrote to V. M. Verkhovskii even earlier (1898): "[The metric system's] immediate introduction as obligatory would be directly deleterious to the success of the matter. *It will come in its own time, and one must think it will be soon.*"[102] The verification establishments offered a means to calibrate the population, which would then gradually, like a compass in a magnetic field, ally itself with the metric system. The important point was not to make the

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[101] "Note from the protocol of the fourth [all-Russian trade-industrial] conference," 9 August 1896, *MS*, vol. 22, 329–30. On the difficulty of introducing the metric system in practice, see Arthur E. Kennelly, *Vestiges of Pre-Metric Weights and Measures Persisting in Metric-System Europe 1926–1927* (New York: MacMillan, 1928). On the turn-of-the-century status of the metric system in Western Europe and North America, see Eastburn, *The Metric System*.

[102] Mendeleev to Verkhovskii, 20 February 1898, RGIA f. 28, op. 1, d. 220, l. 3. Emphasis in original. Mendeleev had advocated optional implementation to Verkhovskii as far back as 21 December 1892, *MS*, vol. 22, 32.

people's bodies metric, but their minds. Metrology—the correlation of individuals carefully guided by a network so pervasive that its actions were unseen and unfelt—provided a mechanism for Mendeleev to adjust the behavior of individuals to meet the needs of a functioning empire.

Conclusion

Mendeleev's enthusiasm for his graduated proposal was just that: enthusiasm. This sweeping optimism had to be tempered as his metric reform collapsed upon the shoals of the political events sweeping Russia in the first years of the 20th century. As crucial as the local bureaus were to Mendeleev's metric reform, it turned out that only 20 had been created by the time of the 1905 Revolution, at which point the budget crunch caused by the Russo-Japanese War forced a halt in construction.[103] The metric reform encountered similar difficulties to other efforts in state building in late imperial Russia. Just as it was essential to impose some kind of effective governance over localities, it was equally important not to strain an already cramped budget or alienate the regions. As often as not, these stumbling blocks were enough to scuttle reform.[104] Furthermore, the bureaus' stamping practices to ensure validity of weights were surprisingly easy to counterfeit, thereby undercutting the supposed protections against fraud.[105]

Mendeleev's death in January 1907 did not stall metrological standardization entirely. The new director, his former assistant at the GPMV Nikolai Egorov, managed to expand the bureaus' capacity, but insufficient funds ham-

[103] As of 1 January 1906 the following bureaus were built: (1) St. Petersburg no. 1; (2) St. Petersburg no. 2 (closed for lack of need); (3) Moscow; (4) Pavlovo (a major producer of weights); (5) Warsaw; (6) Nizhnii Novgorod; (7) Tula and Kaluga; (8) Khar′kov and Voronezh; (9) Nakhichevan′ on Don; (10) Vladimir; (11) Kiev; (12) Odessa; (13) Vilnius (and Minsk); (14) Vladikavkaz; (15) Riga; (16) Kazan′; (17) Saratov; (18) Ekaterinoslav; (19) Perm′; and (20) Ufa; Mladentsev, "Uchrezhdenie Glavnoi Palaty mer i vesov i eia deiatel′nost′," 44. One of Mendeleev's final metrological manifestoes was a 1906 plea arguing for the full implementation of the metric reform by the establishment of the entire array of local bureaus (*MS*, vol. 25, 609). In fact, the battle was already lost. The Ministry of Finance determined, in consultation with the Senate, that although the bureaus that existed displayed extraordinary profitability, they had already saturated the highly industrialized zones, and any further construction would yield diminishing returns. "Predstavlenie Ministerstva Finansov v Gosudarstvennyi Sovet o tom zhe [dalneishem ustroistve mestnykh poverochnykh uchrezhdenii v Imperii i o potrebnykh dlia sego kreditakh, a ravno o nekotorykh izmeneniiakh v deistvuiushchem zakone o merakh i vesakh i v shtate Glavnoi Palate mer i vesov]," 24 May 1907, ADIM Bib. 1052/5.

[104] Elise Kimerling Wirtschafter, *Social Identity in Imperial Russia* (DeKalb: Northern Illinois University Press, 1997), 8.

[105] "O kleimenii torgovykh mer i vesov," 12 June 1901, Moscow, RGIA f. 28, op. 1, d. 263, ll. 66–67ob.

pered progress until 1914 (when the outbreak of world war made achieving financial subsidies well near impossible).[106] At the time the Bolsheviks assumed power in October 1917 and began consolidating it over the rest of the country, the reigning standardization law remained that of 1899—but not for long. On 14 September 1918, Soviet Russia unilaterally and forcibly imposed the metric system, in exactly the fashion Mendeleev had argued against. Enforcement—delegated to the head of the Cheka, Feliks Edmundovich Dzerzhinskii, and then to Valerian Vladimirovich Kuibyshev—typically lagged behind proclamations, and the Sovnarkom did not set up mandatory stamping and verification until 1924; yet by 1927 there were 82 verification stations. Ukraine, Belarus, and Central Asia were metricized in 1922, and in 1923–26 metric committees were established in all the narkoms. A new standardization law did not come into effect until 1934; and the GPMV was finally replaced by the Committee of Measures and Measuring Devices in September 1938, twenty years after imposition of the metric system.[107] The Soviet Union perceived the compulsory introduction of the metric system as crucial to its "modern" image, and the slow rate at which it took in the countryside was pointed out by Western commentators as a sign of backwardness.[108] Although it built on the heritage of imperial frameworks, however, the full story of the imposition and enforcement of the metric system in the Soviet Union offers a narrative of Soviet governance that remains unwritten.

Any account of the final success of the metric system in Russia would have to begin with a consideration of three historical phases of imperial standardization considered here, pivoting on Mendeleev's crucial contributions. Many of the modern scientific and technological developments in the West that Russia coveted after the loss of the Crimean War were at least partially wedded to the metric system, and sharing in these advances would be greatly simplified if Russia implemented the metric system to a greater or lesser extent. D. I. Men-

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[106] [Egorov] draft letter, January 1908, RGIA f. 28, op. 1, d. 362, ll. 11–11ob.

[107] On the Soviet metric reform, see I. E. Gorodetskii, "100 let gosudarstvennoi sluzhby mer i vesov," *Vestnik mashinostroeniia*, no. 5 (1945): 59–62; V. A. Barinov, "50-letie russkoi metrologii," *Nauka i zhizn'*, nos. 11–12 (1943): 42–44; A. G. Vlasov, "Istoricheskaia spravka po vvedeniiu metricheskoi sistemy v SSSR," *Metrologiia i poverochnoe delo*, no. 3 (July 1938): 8–12; Leonid Dmitrevich Isakov, *Na vse vremena, dlia vsekh narodov: Ocherki po istorii metricheskoi sistemy* (Petrograd: Izd. Glavnoi Palaty mer i vesov, 1923); *Metricheskaia reforma v SSSR*; V. O. Arutiunov and M. G. Boguslavskii, "Istoricheskii obzor razvitiia gosudarstvennoi metrologicheskoi sluzhby v SSSR," in *D. I. Mendeleev*, ed. Boitsov, 151–60; V. O. Arutiunov, ed., *50 let metricheskoi reformy v SSSR* (Moscow: Izd. Standartov, 1972).

[108] Kula, *Measures and Men*, 279. For a Western reaction to the Soviet failure to implement the metric system effectively, see Kennelly, *Vestiges of Pre-Metric Weights and Measures Persisting in Metric-System Europe*.

deleev's system was supposed to make this possible, being centralized for accuracy, unified for efficiency, and locally distributed in verification establishments for enforcement. Both Paul and Nicholas had tried to standardize weights and measures in part so they could have a uniform empire. It was only in the precision phase, however, that the measures became uniform enough, the systems integrated enough, that the "net" of local bureaus could potentially transform Russia into a metrologically uniform empire. Standardization, in the general sense of the term, was a common project among European states in the 19th century; and while over time the Russian government increasingly integrated its reforms into the general international context, these reforms never lost their great specificity to Russian circumstances and styles of governance. Metrological projects are always exercises in determining and correlating scales; and the Russian empire, like every other state, correlated its measure to its perception of itself.

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