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Measuring Up to Modernity: Metrological Reform in China, 1870s-1940s

DISSERTATION

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ABSTRACT OF THE DISSERTATION

Measuring Up to Modernity: Metrological Reform in China, 1870s-1940s

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This dissertation examines the early history of the meter, the liter, and the kilogram in modern China. In the last decades of the nineteenth century, foreign and Chinese elites began to condemn the profusion of different metrological practices and systems across China as chaotic and backward. The growing consensus that China needed to have one measure produced different proposals for standardizing weights and measures in late Qing (1644-1911) and Republican China (1911-49). In the Nanjing decade (1927-37), the Guomindang (GMD) government ratified one of these possibilities, setting out a two-track plan for China to embrace the metric system within a few years. This study analyzes records produced by the different groups which lobbied for, led, conducted, and responded to the Nanjing government's metrological reform to specify the objectives, priorities and values which animated it. Officials from the National Bureau of Weights and Measures insisted that they were enforcing an orderly, scientific system of measurement which would inculcate modern habits of mind and practice in Chinese society; facilitate economic planning and China's industrialization; and, the development of science in China. In practice, the comprehensive, exacting regulatory regime they established to keep every instrument and act of measurement in line worked to assert the

Nanjing government's absolute and ultimate authority over all metrological matters in China. In the 1930s, the state-building project to ensure compliance with the legal system of measurement produced mixed results among diverse metrological communities which found that they had to contend with an intrusive, demanding state in addition to choosing metrological practices which served their own needs for order, convenience, and legibility. Metrological reformers had to respond to merchants who refused to give up their old tape measures and steelyards, and scientists who asserted their right to design China's system of measurement. When they did so, they clarified that metrological reform sought, above all, to centralize metrological authority in the Nanjing government, and consolidated the considerable progress towards national metrological standardization achieved by a national network of inspectors of weights and measures.

INTRODUCTION

IN THE BALANCE: STANDARDS, SCIENTIFIC MODERNITY, AND THE STATE IN REPUBLICAN CHINA

In November 1947, Chen Wanxi found himself being transferred to the headquarters of the municipal police force in the northern city of Tianjin. The report explaining the cause of his arrest had been penned by Zheng Guobin, the head of the first division of the municipal police. Zheng's single-page report included a brief statement from the young delinquent: "I make my living selling bananas. Because I use a big scale, my prices are high, and I have no customers. Everyone else uses a small scale. Hence, I bought a small scale." Zheng added that the scales had been inspected, and that he was dispatching both the offender and the damning evidence— the "fake" (*wei*) scales— to be dealt with accordingly.[1]

Chen's misdemeanor came after a revolution in measurement. In fact, his actions had only become criminal because of the metrological sea change which had taken place during the preceding decades. According to Zheng's report, Chen had particular reasons for his choice of scales: his selection had been dictated by the expectations of his customers, and by the type of instrument that was widely used by others, presumably including his fellow peddlers. A century ago, Chen's choice and his rationale would not have raised an eyebrow because that was how people decided what kinds of instruments of measurement to use. In late Qing China (1644-1911), people tended to use the same units and instruments of measurement as those who plied the same trade. However, contrary to twenty-first century sensibilities, it was not customary to use those same units and instruments to measure other things, or even for measuring the same

[1] Guobin Zheng, "Wei chengsong Chen Wanxi xingshi weibei dingcheng zhi duliangheng yian qing" [Pertaining to the dispatching of Chen Wanxi, who violated legal weights and measures (regulations)], file J0219-3-013789, Tianjin Municipal Archives (TMA).

thing in another region. When foreign missionaries and Chinese officials provided details about local weights and measures in response to surveys initiated in the late nineteenth and early twentieth centuries, they reflected the reality that the meaning of units like *chi*[2] shifted depending on what and where they were measuring. In most regions, people were familiar with "cloth rulers" (*bu chi*) and "wood rulers" (*mu chi*), but they often did not line up with each other, and also tended to differ from the cloth rulers and wood rulers used in other provinces or counties. Typically, some local mercantile associations, especially those for merchants of staple goods like rice and salt, tended to standardize weights and measures within their own trade through practices like commissioning the production of tools of their trades, or periodically checking instruments of measurement against local standards. In contrast, other groups like itinerant fruit peddlers tended to use weights and measures which were more casually maintained by expectation and custom. Thus, people were used to and used a mélange of different metrological systems and practices, some more formally enforced than others.

By the middle of the twentieth century, as Chen learned, this metrological fluidity had dried up. People were no longer free to stretch or shrink their *chi* depending on whether they were measuring cloth or wood, and it had become illegal to elect to use a certain type of scale because it was the type that was popularly used within a certain trade in a particular place. People like Chen were flouting metrological statutes which had been promulgated by the Guomindang (GMD, Nationalist Party) government. Soon after the GMD established a new capital in Nanjing in 1927, its government unveiled a new national system of measurement which was meant to serve everyone from customs officials to physicists and peddlers. In particular, the Law of Weights and Measures (1929) contained an authoritative list of official

[2] A unit of length.

names and definitions for units of measurement which everyone in the country was supposed to draw from if they wanted to measure anything.[3] Under this new metrological regime, every ruler in China had to reflect the units laid out in the Law of Weights and Measures, and only those units. Once everyone was inducted into the new system of measurement, a one-*chi* wooden plank was supposed to line up exactly (or almost exactly) with one *chi* of cloth, which would in turn be the same length as another one *chi* of cloth cut in a neighboring stall or a faraway city. Similarly, people were supposed to use only weights which reflected the units laid out in the legal system of measurement. Metrological regulations expressly prohibited the manufacture, sale, or use of instruments which reflected units of weight other than those sanctioned by the Nanjing government.

The Nanjing government's directives dramatically shrunk China's metrological universe. Legally at least, there was now a much-reduced menu of units and instruments of measurement people could choose from when they wanted to measure anything. In the 1930s, the people laying out fare tables detailing the cost of transporting goods by railroad found that they could not continue using their mixture of English pounds, metric kilograms, and Chinese catties.[4] Government officials also pushed publishers of newspapers to use only the names of units of measurement listed in the Law of Weights and Measures when they printed economic information; they also called on organizers of track and field competitions to name events using the official names for units of measurement.[5] The owners of businesses that produced instruments of measurement, and itinerant artisans were told that they could only make very

[3] Gongshang bu [Ministry of Industry and Commerce], *Gongshang bu duliangheng tuixing weiyuanhui huiyi huibian* [Compilation of meeting materials of the meeting of the Metrological Reform Implementation Commission of the Ministry of Industry and Commerce] (Nanjing: Zhonghua yinshua gongsi, 1930), 21-22.
[4] "Zhongyang duliangheng xingzheng xiaoxi: Guanyu Quanguo dulianghengju fangmian" [Updates on central weights and measures administration: Regarding the National Bureau of Weights and Measures], *Duliangheng tongzhi* [Weights and Measures Companion], no. 8 (Jan 1934): 5.
[5] Ibid.

specific types of rulers, steelyards and weights, and, scoops and receptacles. And, of course, officials, surveyors, housewives, and businessmen of all stripes were told that they had to replace their well-worn instruments with ones which reflected the official system of measurement.

But between the 1870s and 1940s, what changed was not just the units and instruments of measurement people were allowed to use. By the time the GMD government turned its attention to metrological reform in the late 1920s, what had also shifted was the meaning of measurement. Beginning in the late nineteenth century, foreign missionaries and Chinese elites started to reframe China's metrological landscape as a chaotic jumble which indicated its socio-cultural deficiency. These critics also highlighted that the treacherous unreliability of units like *mu*[6] and *jin*[7] made it difficult to collect statistics, fettered domestic and international commerce, and hamstrung the transmission of information, including scientific knowledge. In response, different groups of officials and experts set out various paths for China to achieve the emerging international norm of national metrological standardization. When the GMD government ratified one of these proposals as the law of the land in 1928 and 1929, measurement had become more than just a technical trifle. In the 1930s, Chinese people were invited not just to switch to new units of measurement, but to forge the basic building blocks for establishing a unified China, facilitating industrialization and economic development, and for embracing scientific modernity in their everyday lives.

What was also new was how the Nanjing government pursued metrological standardization. The Nationalists were not the first rulers of China to issue directives about the rulers people should use; they were not even the first government in Republican China (1911-49)

[6] A unit of area, commonly used to denote the size of land.
[7] A unit of weight, ubiquitous in many parts of China in commercial transactions, commonly translated as catty or tael.

to do so. But unlike their predecessors, Nanjing's officials enforced the national system of measurement with an exacting, relentless intensity. In the 1930s, officials from National Bureau of Weights and Measures (*Quanguo duliangheng ju*) and its growing network of hundreds of specially trained inspectors of weights and measures (*duliangheng jianding yuan*) established a highly centralized and intrusive regulatory system which worked to keep every instrument and everyone in line with the official system of measurement. This regulatory regime brought the authority of the GMD state to bear on everyday objects like steelyards, and every act of measurement across China, whether these took place at customs offices, laboratories, markets, or homes.

COMING UP SHORT, GOING TO GREAT LENGTHS

This dissertation examines the metrological reform which occurred in Republican China, and the changes which took place before and around it between the late nineteenth and early twentieth centuries. Advocates for metrological standardization, leaders of the Nanjing government's metrological reform, and even some of the inspectors of weights and measures who enforced the new system of measurement believed that it was unacceptable to allow people in China to continue to use a clutter of different systems and practices of measurement. They were not alone in their assessment that some Chinese practices which seemed incompatible with the demands for the modern world had to be done away with. In the decades which sandwiched 1900, foreigners and Chinese elites assessed that China came up short in so many other ways: footbinding was held up as a uniquely cruel maltreatment of women; it became unacceptable that people in China spoke a babble of mutually unintelligible dialects rather than a common tongue;

and, Chinese disregard for new standards of public hygiene was disparaged as another way in which China lagged behind the civilized world.[8]

When they addressed the comparable problem of non-standardized weights and measures in China, leading reformers emphasized that this set of conventions was not just essential, but foundational. Its basic nature made it all the more lamentable that China did not already possess it, and underscored the urgency of their project. People in a variety of other fields shared their conviction that China lacked some of the basic tools that were taken for granted elsewhere. China's first cohorts of modern geologists who returned from graduate training overseas early in the twentieth century were appalled to realize that domestic levels of knowledge about China's territory paled in comparison with what foreign geologists had managed to piece together. The subsequent push to survey China, which the Nanjing government supported at least in principle, was an effort to make good this inadequacy as well as a preparatory step for mining China's mineral wealth.[9] Between 1915 and 1927, the group of physicians, educators and publishers who comprised the Joint Terminology Committee (JTC) shared similar motivations when they did the tedious work of coming to a consensus on Chinese-language terms for anatomical parts in order to support the teaching and practice of western biomedicine in China.[10] In the same period, Chinese social scientists found that they had to introduce the novel idea that empirical observation, in contrast to the more familiar method of textual study, was a valid method which could produce facts about Chinese society. They could not establish the social scientific survey

[8] Dorothy Ko, *Cinderella's Sisters: A Revisionist History of Footbinding* (Berkeley: University of California Press, 2007); Gina Anne Tam, *Dialect and Nationalism in China, 1860-1960* (Cambridge: Cambridge University Press, 2020); Ruth Rogaski, *Hygienic Modernity: Meanings of Health and Disease in Treaty-Port China* (Berkely: University of California Press, 2014).
[9] Grace Yen Shen, *Unearthing the Nation: Modern Geology and Nationalism in Republican China* (Chicago and London: The University of Chicago Press, 2014).
[10] David Nanson Luesink, "Dissecting Modernity: Anatomy and Power in the Language of Science in China" (PhD diss., University of British Columbia (Vancouver), 2012).

as a procedure to identify areas for reform before they nurtured such a "culture of fact."[11] In these ways, metrological reform was a development of its time: non-standardized weights and measures were identified as a relic of backward China, and standardized units of measurement were advertised as basic building blocks for founding a modern nation-state.

The same concerns at the core of metrological reform animated many other official initiatives. This period witnessed the rise of an expansionist state which took on new responsibilities, and increasingly encroached into the everyday lives of ordinary people in the name of modernity. In the 1920s in the southwestern city of Chengdu, for instance, the warlord Yang Sen inherited and continued programs to inculcate hygienic habits, increase mass literacy, and encourage physical fitness among the city's residents.[12] A recent wave of scholarship, also set in China's cities, has highlighted that this development also entailed significant shifts in the terms on which agents of the state and members of society interacted with each other. Janet Chen's study centering the perceptions, treatment, and lives of the poorest residents of Republican Beijing and Shanghai illuminates that municipal authorities acted both on the new idea that the government had a duty towards the poor, and the novel conception that people had to labor productively to qualify as members of society in running the institution of the workhouse.[13] In Republican Beijing, a similar dynamic was at play in the municipal mental asylum. The birth of the asylum and municipal policemen's pro-active detention of mad people

[11] Tong Lam, *A Passion for Facts: Social Surveys and the Construction of the Nation-State, 1900-1949* (Berkeley, Los Angeles, London: University of California Press, 2011).
[12] Kristin Stapleton, *Civilizing Chengdu: Chinese Urban Reform, 1895-1937* (Cambridge, MA: Harvard University Asia Center, 2000).
[13] Janet Y. Chen, *Guilty of Indigence: The Urban Poor in China, 1900-1953* (New Jersey: Princeton University Press, 2012).

announced a new official obligation towards mad people, but also gave members of society fresh tools to obtain municipal support for the care of troublesome family members.[14]

The Nationalist regime in Nanjing also acted on these imperatives. Most infamously, the New Life Movement launched by Chiang Kaishek, the leader of the GMD government in Nanjing, in 1934 announced the government's concern with matters like whether people combed their hair, the straightness of hats on Chinese heads, and how much noise people made in their own homes. The government asked people to lead more orderly, hygienic, simple, and frugal lives by changing a seemingly endless list of everyday habits. People were supposed to keep their homes and places of work clean and tidy; eat and drink quietly; and, politely wait for others to finish speaking without cutting in. The cumulative effect of everybody leading these new lives was a new, modern China. While the movement did not achieve much in terms of results, through it, the GMD government articulated a certain relationship between the state and a modern citizenry. Specifically, by issuing a moralistic program for everyday life, the GMD state positioned itself as the legal and moral head of the country.[15]

The Nanjing government's metrological reform was a similar state-led project to modernize society at the level of everyday habits and instruments. In contrast to the New Life Movement, national officials and local inspectors seemed to have pursued their objectives more fervently, persistently, and effectively. The national government's approach towards metrological reform was expansive and intensive. Like its predecessors, national authorities certified original standards (*yuanqi*), which served as the material basis for the whole system of measurement, and vice-original standards (*fu yuanqi*), which were meant to serve as local

[14] Emily Baum, *The Invention of Madness: State, Society, and the Insane in Modern China* (Chicago and London: The University of Chicago Press, 2018), 63-85.
[15] Wennan Liu, "Redefining the Moral and Legal Roles of the State in Everyday Life: The New Life Movement in China in the Mid-1930s," *Cross-Currents: East Asian History and Culture Review*, no. 7 (Jun 2013): 30-59.

iterations of the national standards. But in contrast to the looser regulatory regimes of the past, the Nanjing government was also acutely concerned with every other instrument of measurement used by the general population throughout China. Leading officials in the National Bureau of Weights and Measures erected a comprehensive regulatory framework to check the accuracy of every instrument at the point of production, and periodically afterward when it had passed into the hands of its user. At every stage, each instrument was supposed to be carefully assessed by inspectors of weights and measures to check if it was still acceptably faithful to the official system of measurement. Every instrument of measurement thus existed in an endless cycle of inspection and re-inspection, accruing seals or paper certificates attesting to its ability to serve as accurate reflections of the official system of measurement in the hands of ordinary people. Nanjing's officials also zealously policed how people referred to units of measurement, most obviously and directly when they rejected an appeal from Chinese physicists to amend the official nomenclature for units of measurement in 1934-35.[16] The names used to refer to units of measurement, like instruments of measurement, had to be just right. These efforts ensured that the pursuit of standardization, and everything it was supposed to stand for did not remain ideas circulating among a class of elite reformers. National and local officials pushed these ideas onto every instrument and act of measurement across China. This constituted an extraordinary expansion of official concern and control over metrological matters in China.

In the course of their work, metrological reformers believed that they were, in their own way, knitting the country together. Compared to municipal or provincial initiatives, the leaders of metrological reform based in the capital were more keenly aware of the relationship between their work and the goal of national unity. Some of them, most vocally Wu Chengluo, highlighted

[16] See chapter four.

that by ensuring that everyone use the same system of measurement, specifically the one decreed by the GMD government in Nanjing, administrators were helping to unify a country that was wrecked by factionalism and warlordism. For much of the 1930s, the Bureau, especially in the periods under Wu's leadership, was the hub of a national network of inspection centers and branch inspection centers which worked to induct more and more people into the new metrological order. In their everyday work, these local inspectors and their superiors in the capital worked to ensure that all instruments and acts of measurement would reflect the sole and ultimate authority of the Nanjing government. In fact, at times, reformers seemed more concerned about safeguarding and asserting Nanjing's metrological authority than with establishing a simple, convenient system of measurement which worked for everyone in China. A close examination of the GMD government's metrological reform reveals that the scheme to revolutionize measurement was also a state-building project that demanded compliance from everyone who measured anything anywhere in China.

TOWARDS ONE MEASURE FOR CHINA

By the turn of the twentieth century, most advocates for metrological standardization reached the conclusion that the metric system was the best choice for China. Reformers argued that China should adopt the meter (*gongchi*) and the kilogram (*gongjin*) as its basic standards, as many other countries had done. Survey after survey of the state of measurement around the world underlined that the international trend towards metrication was undeniable, and argued that it would be most convenient and advantageous for China to jump on the metric bandwagon. A similar line of thinking had produced the conviction that the survival of China's ideographic script in the modern era depended on its compatibility with the cutting-edge, globally popular

technology of the typewriter.[17] And just as that realization produced the challenge of reconciling Chinese characters with a machine designed for alphabetic languages, metrological reformers were confronted with the difficulty that metric units were very alien to most people in China.

Metrological reformers' answer to this challenge was a two-track approach to the metric system. The national timetable for metrological reform formalized in late 1929 directed official agencies to switch to the metric system directly by the end of 1930. Everyone else, however, was supposed to take a more indirect route to the metric system. Instead of adopting metric units immediately, the rest of the country was supposed to gradually embrace the market system (*shiyong zhi*), an auxiliary system designed specifically to bridge the gap between Chinese metrological habits, and the metric system. After collecting information about weights and measures commonly used throughout the country, reformers formulated a set of basic units for the market system which had the dual advantage of being close to Chinese units of measurement, and directly related to their metric counterparts. In the market system, the market *sheng* (*shi sheng*) was equal to the liter (*gongsheng*), but the market *jin* (*shi jin*) was only half of the kilogram, and the market *chi* (*shi chi*) was a third of the meter. These simple rates of conversion were the basis of the moniker the government used to publicize the new system of measurement: the "1.2.3" system (*yiersan zhi*).

In many ways, metrological reform in Republican China fits the mold of what James C. Scott has called high modernist, large-scale schemes to improve human welfare.[18] Most prominently, the technocratic preferences for simple, obvious order dominated discussions about possibilities for a new national system of measurement for China. In the late nineteenth and early

[17] Thomas S. Mullaney, *The Chinese Typewriter: A History* (Cambridge, MA: The MIT Press, 2017).
[18] James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven and London: Yale University Press, 1998).

twentieth centuries, even after the Nanjing government had announced its official system of measurement, people concerned with rewriting China's metrological future insisted that it had to have the kind of order at the core of the brand of scientific forestry which had been born in nineteenth-century Germany. China's new units of measurement, like the trees, had to line up neatly. There was also a palpable abhorrence of messy practices like the fact that the unit *jin* carried a jumble of meanings which might or might not be related to each other, and that even in a single village a *mu* of land might be bigger or smaller depending on the fertility of specific districts. The broad and fervent commitment to this particular kind of neat order led many to the conclusion that the metric system was the clear choice for China. The metric system had many things going for it. Some of the long essays introducing it to Chinese readers applauded the fact that the meter, the unit of length at the heart of the whole system, was based on the measurement of the length of the meridian running through Paris, a project which had been commissioned and conducted by scientists. It was also commendable that the definition of the meter and the kilogram, and their material standards, had been examined and endorsed by international experts. These were all factors in favor of metrication. But to the people shopping for a new system of measurement for China, the metric system's most important advantage was its strict decimal order. In this system, basic units like the meter came with a list of prefixes which could scale units up or down, only and always by a factor of ten. Thus, the deciliter was a unit of volume equal to a tenth of the liter, and decaliter referred to a unit of ten liters. Furthermore, adding deci- or deca- to any other basic unit like the meter had the same effect. By the 1910s, praise for the metric system focused predominantly on its elegant decimal order: its fans branded it the "decimal system" (*shijin zhi*), and demanded that rival systems match it for its unflinching adherence to the rule of ten. The latter demand might seem unreasonable (since it almost

foreclosed the conclusion that the metric system was the best one), but everyone who designed alternatives to the metric system embraced it as a non-negotiable requirement for China's metrological future.

When reformers turned their attention to engineering metrication in China, they also behaved in ways reminiscent of the modernist planners who had drawn up plans for apartments based on meticulous calculations about the amount of space and sunlight the hypothetical average person needed. They began with a conscientious effort to generate data about the state of weights and measures in China by conducting a nationwide survey. The reformers in Nanjing received voluminous returns from local officials across China. Only a stray few of these reflected a lack of understanding about the survey or only a very cursory effort to document local weights and measures.[19] Most of their respondents dutifully reported the names and dimensions of rulers, scales, and dippers which were commonly used in different locales. Some local officials went the extra mile to convey the state of measurement in their jurisdictions by attaching drawings of local rulers, weights and dippers.[20] One official in Yichuan county (Shaanxi province) thoughtfully included a strip of paper cut to the length of the local ruler used to measure textiles, and officials from Beiping (Beijing) dispatched two kinds of rulers, two types of receptacles, and four kinds of scales to the capital with their returns to the metrological survey.[21] By manually crunching these numbers, a group of planners derived the average values for the *chi*, the *jin*, and the *sheng*, common units for measuring length, weight, and volume respectively, across China. These, in turn, formed the basis for the definition of the market *chi*, the market *jin*, and the

[19] "Sichuan sheng yingshan xian xianxing duliangheng qi jianbiao" [Sichuan province Yinshan county summary table of current instruments of measurement], file 613/401, Second Historical Archives of China (SHAC).
[20] For example "Henan sheng Xuchang xian xianxing duliangheng qi jianbiao" [Henan province Xuchang county summary table of current instruments of measurement], file 613/402, SHAC.
[21] "Shanxi sheng Yichuan xian xianxing duliangheng qi jianbao" [Shaanxi province Yinchuan county summary table of current instruments of measurement], file 613/408, SHAC; "Beiping tebieshi xianxing duliangheng qi jianbiao" [Beiping municipality summary table of current instruments of measurement], file 613/404, SHAC.

market *sheng*— fresh metrological confectioneries which the government insisted closely mimicked "local habit."

To the reformers, these principles and methods had produced the perfect solution to China's metrological mess. They had paved two roads to the metric system, including one that met Chinese society where they were. So when various groups reported that some aspects of the legal system of measurement were unsuitable, or simply refused to use the official system of measurement, the national leaders of metrological reform typically responded with an uncomprehending insistence that the system sanctioned by the Nanjing government was the best one. Officials insisted that every other alternative was inferior, and that proposed modifications compromised the legal system's perfect order. But no one was asking for a messier system of measurement. As the latter chapters of this dissertation will show, the uncooperative groups which held out against Nanjing's metrological reform shared the official commitment to order, simplicity, and convenience. In the 1930s, the scientists who had strong objections to the official system of measurement and the sellers of logs who were searching for a better system to facilitate their trade insisted that they had to have a system of measurement that was simple and orderly. The catch was that their particular metrological needs and concerns had not been written into Nanjing's chosen metrological system. When national officials encountered these road bumps in the course of rolling out the official system of measurement, they went to great lengths to highlight the perfect order of the national system of measurement. But when push came to shove, officials prioritized enforcing Nanjing's chosen metrological order rather than catering to the metrological needs of specific communities.

I begin this study about metrological reform in modern China by interrogating the official narrative that the GMD government imposed order on a chaotic metrological landscape in China.

Chapter one tracks the gradual emergence of the idea that existing metrological practices in China were disorderly, and the insistence that China should and must have only one system of measurement. The second chapter looks closely at the initial stages of implementation of the GMD's metrological reform. It argues that metrological reform was also a state-building project that sought to establish a single regulatory regime of authentication centered in Nanjing. The campaign to enforce one measure for China was also an effort to build one China.

The latter part of this study examines how national officials and local inspectors tried to enforce the new system of measurement, and what happened when they did so. Chapter three analyzes the slow and difficult progress of metrological reform in the 1930s. I argue that agents of the state pursued the very narrow goal of ensuring compliance with the legal system of measurement. In chasing this outcome, the government had a better chance changing tight rather than loose metrological communities, and ignored other concerns that were unrelated to standardization. The final chapter analyzes a dispute between China's scientific community and the government about the legal system of measurement in 1934-35. I argue that the arguments made in the dispute and its outcome reveal that the needs and perspectives of scientists were actually marginal despite the government's broad, intense commitment to enforcing a "scientific" system of measurement in China.

CHAPTER 1 TALES, TALL AND BURIED

INTRODUCTION

In July 1928, the GMD government announced an ambitious plan to revolutionize measurement in China. The Nanjing regime's guidelines for explaining the reform to the public declared that China was a metrological mess. One *jin* (a unit of weight) of coal from Henan province did not balance the scales with a *jin* of raw hide sold in the southern port of Pakhoi (Beihai, Guangxi province). (The raw hide would be heavier.[22]) Even within the same province or city, the *chi* (a unit of length, commonly translated as foot) of a tailor might not necessarily line up with the *chi* of a carpenter. The GMD government planned to remedy the situation by introducing a uniform system of measurement across China between 1930 and 1933. According to this plan, China would be completely and exclusively metric by the end of 1933. The government assured the public that this metrological transformation would facilitate the development of industry, commerce, and science in China, and the country's seamless inclusion in the modern world.[23]

The GMD government's narrative about the state of measurement and what metrication meant for China quickly became mainstream. Most articles on the topic written in the ensuing decades echoed the view that measurement was a mess (*luan*; in confusion or disorder) in the early twentieth century and that the GMD government's pursuit of standardization was commendable progress— even if progress was slow, uncertain, or difficult. These elements also

[22] According to H.B. Morse, "Abstract of Information on Currency and Measures in China," *Journal of the China Branch of the Royal Asiatic Society*, Vol. XXIV (1889-90), 83-84, in Henan, one *jin* of coal was equal to 20 ounces avoirdupois, and in Pakhoi one *jin* of raw hide was equal to 31.83 ounces avoirdupois.

[23] Zhongguo guomindang zhongyang zhixing weiyuanhui xuanchuanbu [Propaganda Department of the Central Executive Committee of the Guomindang], *Huayi quanguo duliangheng xuanchuan dagang* [Outline for Propaganda for National Metrological Standardization] (Shanghai: Zhongguo guomindang zhongyang zhixing weiyuanhui xuanchuanbu, 1929).

feature prominently in the writing of China's modern metrological history. Wu Chengluo, an applied chemist by training and the most prominent leader of the GMD's metrological campaign across the 1930s and 1940s, published an authoritative study of China's metrological history in 1937 which amplified precisely this narrative.[24] Wu's volume reappeared in multiple new editions throughout the rest of the twentieth century and remains a standard resource on weights and measures in China. Chinese language studies of the history of measurement or the GMD government's reform written in the twenty-first century reiterate this tale. The most substantive of this corpus is a book length draft history of metrology which focuses on developments beginning in the late nineteenth century.[25] The footnotes of *Modern and Contemporary Metrology in China* include a generous sprinkling of references to Wu's 1937 book, and its authors laud the Nanjing government for making headway towards the metric system. The GMD might not have done much or done much right during its moment in the sun on the mainland, but historians agree that they made a rare right move for metrology— they made *progress* from mess to metric.

Why did the GMD officials see China as a metrological mess? And how did the metric system come to be held up as an ideal metrological future? By reading overlapping waves of foreign and Chinese writing about measurement between the 1870s and the 1920s when the Nanjing government drafted its metrological blueprint, I track the genesis of these two elements of the dominant narrative framing the history of measurement in modern China and examine them more closely. Who struggled with measurement in China and what interests did metrication serve?

[24] Chengluo Wu, *Zhongguo duliangheng shi* [History of Metrology in China] (Shanghai: Shanghai shudian, 1937).
[25] Zengjian Guan, et al., *Zhongguo jinxiandai jiliang shigao* [A Draft of the History of Modern and Contemporary Metrology in China] (Jinan: Shandong jiaoyu chuban she, 2005).

In the late nineteenth century, the idea of measurement in China as chaotic initially came from foreigners who felt that China needed broad and deep changes to adapt to a modern world. In the final decade of the Qing dynasty (1644-1911), Chinese reformers echoed this assessment as they began a budding fascination with the metric system. But in 1908 the Qing court affirmed its commitment to measures which had been verified during the reign of the Kangxi emperor (r. 1661-1722) although it had obtained its own copies of the metric standards held in France. In 1915, their Republican successors in Beijing only allowed the metric system to be used concurrently with Qing weights and measures. Between then and the announcement of the GMD reform in 1928, the inconvenience of metric units for measuring electromagnetic forces led a small corps of scientists and engineers to search for a more perfect system of measurement. They produced various alternatives to the metric system. But these did not prove as attractive as the metric system to the officials tasked with redesigning China's system of measurement between 1927 and 1928.

By examining these discussions about measurement in China, I go beyond the conventional understanding that the GMD reform represented commendable progress to specify the principles and priorities undergirding this reform. In this instance, the Nanjing government inherited and acted upon the assumption that it was essential and modern for China to have only one system of measurement. The final metrological scheme was also clearly marked by the requirements of centralized legibility and control. Officials prioritized this need over other metrological communities and needs in choosing from the possibilities available to them. These twin commitments— to singular order, and convenience for centralized control— meant that the existing practices and needs of groups like market stall holders and scientists fell by the wayside in the planning of China's metrological future. Contrary to official propaganda, the needs of

those who measured in small shops or stalls, and laboratories were compromised in favor of the units which could support a certain vision of centralized economic planning and development in China.

CONSTRUCTING CHINESE CHAOS: ONE MEASURE FOR CHINA

China's units of measurements were simply alien to foreigners when they arrived in search of profit. When foreign traders were mostly confined to Canton (Guangzhou) in the southern province of Guangdong in the eighteenth century, the weights and measures used in that port were included in handbooks which bore titles like *An Authentick Account of the Weights, Meafures, Exchanges, Cuftoms, Duties, Port-Charges*.[26] For the trader who picked up these volumes in London, Canton was just like Bengal, Malacca, and Surat— the officials in those ports would use local measures to calculate duties and such handbooks helped foreigners to find their (metrological) feet on foreign soil. They informed foreign traders that the officials in Canton would calculate duties using the pecul (picul),[27] a unit of weight, and the covid, a unit of length, using instruments issued to the Custom House by the Qing's Board of Revenue. A pecul was equal to 132 and two-third pounds avoirdupois[28]; the covid was equal to fourteen and five eighths of an inch.[29] Fees were collected in either gold or silver, weighed out using the units cafh, candarine, mace, and tael. The tael, like the pecul, was defined using the pound avoirdupois. A "Memorandum of Elephants Teeth" (ivory), which was printed in more than one handbook, demonstrated the system in practice. Three tusks of the "first sort" (i.e. the highest quality) would weigh a pecul and was charged a duty of 45 tael per pecul whereas six teeth of the

[26] Samuel Jackson, *An authentick account of the weights, measures, exchanges, customs, duties, port-charges, &c. &c. and correct Batty tables, made use of, and paid at the several ports of the East-Indies, traded unto by Europeans* (London: W. Lear, 1764), 50.
[27] A unit of weight used in China and South-East Asia equal to 100 catties (approx. 133 lb, 60.4 kg).
[28] Note: 1 pecul= 100 cattys; 1 catty= 16 tael.
[29] Jackson, *An authentick account*, 50.

"fourth sort" (also weighing a pecul, i.e. smaller tusks) would be taxed at only 39 tael per pecul.[30]

China's units of measurement, like the ubiquitous pecul, were unfamiliar. But this was a straightforward problem which was easily solved with codified rates of conversion. These rates marked Chinese units of measurement as different from those that westerners were familiar with, but they also deftly neutralized the difference. A few short lines allowed foreigners to bridge the metrological gap between home and China. Peculs could become pounds.

The treaty port era, inaugurated with the Treaty of Nanking (1842), continued the use of these standards and units. Article IX of the "General Regulations under which the British Trade is to be conducted at the Five Ports of Canton, Amoy, Foochowfoo, Ningpo, and Shanghai," an agreement appended to the treaty, specified that British consuls at each of these five ports should receive a replica of the standards "in exact conformity to those hitherto in use at the Custom-house of Canton." These standards were to be the ultimate arbiter of the duties owed to the Qing, and all commercial disputes.[31] The only (insubstantial) difference was that the treaty's schedule of duties primarily used the unit catty rather than the pecul. The drafters of the Treaty of Tientsin (1858) followed these precedents. Consulates at all ports were to receive a copy of the "standard issued to the Canton Custom-House by the Board of Revenue."[32] Representatives of Britain and China agreed to adjust the duties to be charged, but not the units or methods with which these were to be calculated.

To some extent, foreigners could even live without the irritation of Chinese units of measurement. Life could take place within a metrological bubble. The members of the North

[30] Jackson, *An authentick account*, 65.
[31] Treaty between Her Majesty and the Emperor of China, signed, in the English and Chinese languages, at Nanking, August 29, 1842. With other documents relating thereto., 8-12.
[32] Treaty of Peace, Friendship and Commerce, between Great Britain and China, signed at Tientsin, 26th June, 1858.

China branch of the Royal Asiatic Society (RAS) relied only on inches and feet, whether they were describing a monument to Manchu clemency in Korea (a rectangular plaque mounted on a tortoise, erected in 1639) or recording the height of bores (a type of wave) in Hangzhou bay on China's eastern coast.[33] In the 1920s, columns addressing female residents of Shanghai exclusively used British units. One anxious reader of the section called "Milady Beautiful" asked Lois Leeds of *The China Press*, how she could control her appetite since she was "18 years old, 5 feet 3 inches tall and [weighed] 132 pounds." In response, Lois prescribed lettuce, spinach and bran crackers since "You are already thirteen pounds above the average weight for your age and height."[34] The author who wrote the column "Shopping About Town with Jeanette," urged "Shanghai wives" to take advantage of sales where they could buy cloth between $2.30 to $28 per yard at a shop along Nanking Road or 16-ounce, 24-ounce and 32-ounce bottles from the American Drug Company.[35] In another column, she instructed her readers to roll the dough for Bohemian fruit rolls till they were "1/2 inch in thickness."[36] In another, she personally attested to and marveled at how the gears of a Jewett automobile shifted "from high to second at 30 miles—with barely a sound."[37] One imagines that the Chinese servants in foreign households would have had to toggle between foreign and Chinese units of measurement, but to some degree their mistresses might have lived with ounces and inches, insulated even from the mild inconvenience of conversion.

[33] W.B. Carles, "A Corean Monument to Manchu Clemency," *Journal of the China Branch of the Royal Asiatic Society,* Vol. XXIII (1888-90), 2; Commander R.N. Moore, "The Bore of the Tsien-tang Kiang (Hang-chau Bay)," *Journal of the China Branch of the Royal Asiatic Society,* Vol. XXIII (1888-90), 234.
[34] Lois Leeds, "Milady Beautiful Beauty Questions Answered," *The China Press,* Oct 1,1928, 12.
[35] "Shopping About Town with Jeanette," *The China Press*, Feb 8, 1925, 5; "Shopping About Town with Jeanette," *The China Press*, Mar 1, 1925, 5; "Shopping About Town with Jeanette," *The China Press*, May 17, 1925, 5.
[36] "Shopping About Town with Jeanette," *The China Press*, May 3, 1925, 5.
[37] "Shopping About Town with Jeanette," *The China Press*, May 24, 1925, 5.

But in the last three decades of the nineteenth century, some expatriates began to see measurement as a different kind of problem. They did not merely chafe at the nuisance of converting quantities to local units of measurement. They began to write about the chaotic state of measurement in China. This new, negative view of measurement in China emerged between the 1870s and 1900s. In this period, some foreigners began to complain that the problem was that people in China used a bewildering variety of units of measurement. The conversion rates for the singular "catty" belied the fact that it did not have a fixed definition across China. This variability applied to other units of measurement too. Foreign perception of measurement in China shifted from simple difference to unordered chaos.

It was a particular class of men who took the time to articulate this new view of measurement in China. They were not men who were just passing through, and they were not in China incidentally. Typically, they spent years, if not decades, of their lives in China and they were dedicated to, or at least caught up with, the grand project of changing China. Their objectives ranged from saving Chinese souls and teaching English and science to paving the way for commerce in China. Many of them clustered around the assortment of institutions which were established to help the Qing throne deal with the demands being placed upon China from other countries. The textbook example here is Sir Robert Hart, the capable Irish Inspector-General who shaped the Chinese Maritime Customs into a formidable organization for collecting customs revenues in more than fifty treaty ports on behalf of the Qing. Hart, like so many other foreigners, believed that China could and should change for the better.[38] Specifically, it should become more like the west.

[38] Jonathan Spence, *The China Helpers: Western Advisers in China 1620-1960* (London: The Bodley Head, 1969), 93-125.

One of the foreigners who was among the first to articulate the idea that China was a metrological mess well-exemplified the intentions and experiences of this group. The American William Alexander Parsons Martin (W.A.P Martin) arrived in China in 1854 as a Presbyterian missionary. He was first posted to the eastern city of Ningbo (Zhejiang province) where he met a young Robert Hart, then just an interpreter working in the British foreign service. (It was the beginning of a long friendship which included Martin taking cover with Hart during the Boxer siege of the foreign legations in Beijing in 1900. Martin wrote movingly of the terror and anguish both men felt during this event, a sign of the apparent failure of their efforts to reform the Qing and China.) Reverend Martin did not enjoy much success with his original mission of spreading Christianity in China. This frustration led him to the conviction that, regrettably, there was only a longer and more circuitous route to a Christian China. For Martin, westernization became an essential first step towards Christianization. In 1863, he collaborated with Chinese scholars to translate Henry Wheaton's *Elements of International Law*, the first of a significant number of translations with a special emphasis on international law. Taking his cue from the career of the Jesuit Matteo Ricci in China, Martin also saw scientific education as one of the cornerstones of spreading the best of western civilization to China.[39]

W.A.P Martin had the opportunity to act upon his convictions when he became the head of the Tongwen Guan, variously translated as the School of Combined Languages or the School of Combined Learning, which had been established in the wake of the Second Opium War (1856-1860) in 1862. It was charged with training interpreters for its parent agency, the Zongli Yamen (Office for the General Management of Affairs Concerning the Various Countries), the imperial agency overseeing foreign affairs for the Qing. The Tongwen Guan was plagued with

[39] Ibid., 130-59.

difficulties from the start. Recruiting and retaining qualified language instructors was an uphill task. When Martin took up a position teaching English in 1865, he was entering a department which had already lost a number of other teachers including John Fryer, another former missionary who became a translator of scientific texts at the Jiangnan Arsenal.[40] Studies of the 1867 dispute surrounding a proposal to establish schools for mathematics and astronomy within the institution also frame the Tongwen Guan as a battleground where factions advocating a more wholesale embrace of western science failed to prevail over conservatives who continued to prioritize the preservation of Chinese culture and learning.[41] On the whole then, the Tongwen Guan was typical of the vacillation and half-heartedness which characterized late Qing efforts to save itself and China. Martin's promotion to head instructor in 1869 seems to have been a bright spot in the school's history. He reinvigorated the institution. His long tenure as the head of the Tongwen Guan (till 1895) witnessed the establishment of science departments in an institution originally designated only for the study of foreign languages and the development of an eight-year curriculum which featured western history, geography, mathematics, physics, chemistry, mechanics, and political economy and international law.[42]

The head of the Tongwen Guan published an essay titled "The Metric System for China" in 1874.[43] Martin's convictions that it was the character of Chinese society which needed changing and that science was the key to this change weave through this essay. The Reverend began by arguing that the state of measurement in China was deplorable. He acknowledged that China had a "general" system of measurement based on lining up grains (millet) and the pitches

[40] Melissa Mouat, "The Establishment of the Tongwen Guan and the Fragile Sino-British Peace of the 1860s," *Journal of World History*, 26, no. 4 (Dec 2015): 735, 751-54.
[41] Lawrence Wang-chi Wong, "'Entrance into the Family of Nations": Translation and the First Diplomatic Missions to the West, 1860s-1870s," in *Translation and Modernization in East Asia in the Nineteenth and Early Twentieth Centuries*, ed. Lawrence Wang-chi Wong (Hong Kong: The Chinese University of Hong Kong Press, 2018), 166.
[42] Ibid., 171-72.
[43] W.A.P Martin, "The Metric System for China," *The Chinese Recorder and Missionary Journal*, Mar 1, 1874, 57.

of a pipe called the *huangzhong*. Martin noted that Qing statutes theoretically laid out the system of measurement for the empire. He even conceded that it was "not altogether destitute of a scientific foundation," given that it equaled the metric system in the extent to which it adhered to a decimal order.[44] [45] Furthermore, he noted that there was widespread understanding of the system. The catch was that no one used the legal metrological system, not even for the collection of the grain tax. Instead, "the term catty changes its signification with almost every article of domestic consumption," and the definition of the foot shifts "with an inconstancy which defies all rules."[46] Martin complained that one could not even count on metrological stability within a single store; shopkeepers typically switched between different scales for different transactions. For Martin, the problem was not that China had a different system of measurement. The problem was that Chinese people randomly deviated from the (orderly) formal system of measurement; they seemed to define units as they saw fit. For Martin, China had one system of measurement and an unordered gaggle of units of measurement.

China's metrological landscape disturbed Martin because it betrayed a deeper cultural defect. Certainly the lack of standardized weights and measures throughout China was inconvenient for foreign commerce. However, this was not the main reason behind Martin's insistence on reforming metrology. Martin felt that material standards were "a kind of visible conscience," and that those who measured with precision— using scales which "tremble at a breadth of a falsehood"— were the kind of people who have been "educated in honesty and fair

[44] Ibid.
[45] The existence of an orderly Chinese system of measurement haunts the modern history of metrology in China. At different points, individuals would dream of reviving it for the modern period.
[46] Ibid.

dealing." Conversely, societies which lacked accurate standards were "a people among whom commercial morality is, to say the least, *somewhat* lax."[47] (emphasis original)

Martin argued that everyone in China should use only one system of measurement. He understood that "for practical purposes" it did not matter whether standards were based on "the claw of a dragon, or the palm of a man."[48] The throne simply had to set units of measurement and ensure that they were used *exclusively* throughout the territory. Since China already had standards, Martin noted that all that was necessary was strict or stricter enforcement. Yet, as his title indicated, this was not the course of action which Martin urged the court to take. He argued that China should go metric because it was the most internationally popular, and, hence, the most convenient system of measurement. At the end of a long list of countries which had either adopted or allowed the use of the metric system, Martin underlined that the global pro-metric tide was undeniable. China would be following in the footsteps of "civilized" nations if it embraced the metric system. To this end, Martin had collaborated with a number of Frenchmen to translate some tables explaining the metric system and also provided a standard history of the meter from its birth in revolutionary France to its international career.

When Martin's friend the American missionary Arthur Henderson Smith reflected on weights and measures in China a decade and a half later, it seemed that nothing had changed. Smith was a more colorful writer than Martin. His mediations on measurement are contained in a chapter in *Chinese Characteristics*, a collection of articles which first appeared in the *North China Herald*. In each chapter, Smith distills the essence of some Chinese quirk, often illustrated with anecdotes collected throughout his extended stint in China. His remarks on measurement include snippets about an ex-soldier who comically left out his own neck and head in reporting

[47] Ibid.
[48] Ibid.

his own height; a hapless farmer who subtracted the weight of bones when he stated the weight of his oxen; and, a clueless rustic who calculated the distance between his home and a nearby town by including the journey to and from the destination. His humorous style no doubt partially explains the popularity of *Chinese Characteristics* after its first appearance in 1890. It became one of the most widely-read books about China into the early twentieth century.[49]

Smith wrote about measurement in China in a chapter entitled "The Disregard for Accuracy." Chinese indifference to accuracy was not limited to metrological matters. Smith railed against so many other types of imprecision, including the varying pronunciation of characters in different regions (dialects), and even the vague ways in which the Chinese spoke of people's ages in decades. But most of this lengthy chapter is dedicated to "standards of quantity," the "the absolute invariability of which so much of the comfort of Western life is found to depend."[50]

Smith had two major criticisms about measurement in China. His first major bugbear was that there were no standardized units of measurement. No standard held across China. The meaning of "one hundred pieces of brass cash" meant thirty-three pieces in Zhili (present-day Hebei province) and eighty-three pieces in Taiyuan, the capital of Shanxi province. The "ounce" used to buy and sell silver morphed from place to place, only coinciding "by accident" according to Smith.[51] His list of other unreliable units of measurement included the catty and the acre. He reserved special ire for the *li*, the unit most commonly used to denote the length of journeys. The Chinese stretched the *li* for roads that were easily-traversed like imperial highways. Conversely, they shrunk the *li* when it was used to describe journeys on unpaved, winding, or uphill roads.

[49] Lydia H. Liu, *Translingual Practice: Literature, National Culture, and Translated Modernity—China, 1900-1937* (Stanford: Stanford University Press, 1995), 51.
[50] Arthur H. Smith, *Chinese Characteristics* (Shanghai: North China Herald Office, 1890), 78.
[51] Ibid., 79.

Smith recognized that there was "*some* basis" (emphasis original) for these adjustments but specified that he was frustrated by the fact that these estimates were neither accurate nor uniform.[52] In all these cases, Smith was frustrated that Chinese people seemed to pick any measure they wanted without regard for any set or shared standard. He saw evidence of the "fluid" nature of standards in China in how the sellers of steelyards seemed to customize the "stars" or markings on these ubiquitous instruments of measurement according to the demands of individual customers.[53] For Smith, bespoke steelyards betrayed everything measurement should be about.

Arthur Smith was also exasperated by how carelessly the Chinese counted or measured. He noted that they were slipshod in other ways too. For instance, they sloppily used homophones when they wrote the names of places, creating a confusing proliferation of varying designations. They were similarly imprecise with counting, preferring to refer to "tens," "hundreds," or "thousands," and finding western demands for "unerring exactitude" perplexing. He ridiculed the negligence of people who could ask him "four nines are forty, are they not?"[54]

Beyond measurement, *Chinese Characteristics* paints a highly unflattering portrait of China in contrast with an advanced Occident. Smith unfavorably compares the Chinese person's embeddedness within and obligations to a sprawling familial network— with members both dead and alive— to the western principle of the individual as the basic unit of society.[55] Chinese parochialism is set against western cosmopolitanism; charitable efforts in China are exposed as ad hoc and insincere compared to European philanthropy; and, the stubborn Chinese proclivity

[52] Ibid., 80-2.
[53] Ibid., 82.
[54] Ibid., 82.
[55] Ibid., 9-11.

for oblique communication is portrayed as infinitely inferior to frank directness.[56] Smith's comments about measurement in China conforms to this pattern. Chinese practices of measurement were deficient compared to western metrological order. In *Machines as the Measure of Men*, Michael Adas incisively notes that Smith was part of a generation of westerners who were belatedly applying the standard of technological superiority, including the practice of precise measurement using standardized units, to non-western societies in the nineteenth century.[57] [58] Measurement was just another way in which China fails to measure up to the west. Like Martin, Smith felt that "the Chinese are capable of learning minute accuracy in all things," but "as at present constituted, they are free from the quality of accuracy, and they do not understand what it is."[59]

The next wave of foreign writing about Chinese measurement inherited this perspective as well as the missionaries' civilizing discourse. But the new complaint was that the disordered state of weights and measures deprived foreigners of the most elementary tools to understand China, and in particular, the state of China's economy. They did not check units of measurement to take the temperature on China's cultural deficiency; non-standardized units of measurement hindered their efforts to collect information and understand various aspects of China's economic landscape.

Beginning in 1888, leading members of the north China branch of the RAS undertook a series of surveys with this objective. The first was a monumental study surveying the state of

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[56] Ibid., 15-7, 124-30, 138-44.
[57] Michael Adas, *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance* (Ithaca and London: Cornell University Press, 1989).
[58] Adas' reading of Smith's writing about measurement is accurate. But it is inaccurate to say that this is the overarching framework which Smith, presumably like his contemporaries, used to judge China as backward—an idea which is central to the thesis of Adas' book. Smith's broader conclusions about China in the volume are based more heavily on socio-cultural factors rather than a society's ability to carry out the kind of scientific and technological feats which characterized Britain after the Industrial Revolution.
[59] Smith, *Chinese Characteristics*, 84.

land tenure in China led by the society's president George Jamieson. The RAS asked respondents to answer questions like "What is the average size of the agricultural holdings or Farms in the part of the Country best known to you?" and "What is the average annual production per mou—say of rice (paddy) or barley—by weight, and what is the local selling price?"[60] When the paper was read to a general meeting of the society on February 22, 1889, one member, Mr. G.J. Morrison, suggested that each respondent should be asked to provide a supplementary statement about "the precise nature and value of the measures they gave." Without pinning these units down, "the Society might only be the means of circulating misleading information" about China's agricultural production. Jamieson agreed with Morrison's suggestion and mentioned that the RAS had recently embarked on a survey which addressed the variation of measures across China.[61] The society's circular, published in January 1889, called for respondents throughout Qing China to provide details about the types of currency, and weights and measures being used in different parts of the empire.[62] In November that year, the secretary of the RAS extended the call for information because of the small number of responses.[63]

Nevertheless, the society published a preliminary summary of the results of this survey in early 1900. This article compiled data supplied by 30 respondents (almost all missionaries) located in different parts of China. The paper also indicated that the society's study was incomplete; it continued to seek clarifications and new data sets from respondents around the country. Compared to previous commentary on metrology in China, there was a new aspiration

[60] George Jamieson, "Tenure of Land in China and the Condition of the Rural Population," *Journal of the China Branch of the Royal Asiatic Society*, Vol. XXIII (1889): 59-60.
[61] "Minutes of a General Meeting held at the Society's Library on Friday, 22nd February, 1889," *Journal of the China Branch of the Royal Asiatic Society*, Vol. XXIII (1889): 182.
[62] "Chinese Currency, Weights and Measures," *The North China Daily News*, Jan 9, 1889, 23.
[63] Wm. Bright, "The Currency and Measures of China," *The North-China Herald and Supreme Court & Consular Gazette*, Oct 4, 1889, 418.

to paint a complete, correct, and detailed overview of measurement in China. Essentially, the RAS conducted a social scientific survey of weights and measures, and currency in China. Its 1900 paper replaced the colorful string of anecdotes from men like Reverend Martin and Arthur Smith with summary tables populated with numbers. These tables enumerated China's metrological mess with a new specificity. The judgment that "chaos reigns supreme through the whole of the Empire" was fleshed out in numbers.[64] Each unit of measurement was disassembled into its various iterations in different parts of the empire for different commodities.

The RAS member who compiled this preliminary paper was Hosea Ballou Morse. Morse would go on to write the next influential text on weights and measures in China. He was born in the middle of the nineteenth century in Nova Scotia. He started his long career with the Chinese Maritime Customs directly after graduating from Harvard College in 1874. For more than 33 years, Morse supported the treaty port system which allowed foreigners to trade in China. He rose through the ranks, moving from coordinating the postal service in one of his earliest postings in the northern port of Tianjin to the rank of commissioner in Tamsui (Taiwan province) and Yoochow (Hunan province). After his retirement from the Maritime Customs in 1909, Morse went on to a second career as a prolific historian of China until his death in 1934. His best-known work is the triple-volume study *The International Relations of the Chinese Empire*.[65]

Morse wrote about China's weights and measures in his first book *The Trade and Administration of the Chinese Empire* (hereafter *Trade and Administration*). In his review of his mentor's oeuvre, John King Fairbank commented that *Trade and Administration* was "a rather

[64] H.B. Morse, "Abstract of Information on Currency and Measures in China," *Journal of the China Branch of the Royal Asiatic Society*, Vol. XXIV (1889-1900): 48.
[65] John King Fairbank, Martha Henderson Coolidge, Richard J. Smith, *H.B. Morse: Customs Commissioner and Historian of China* (Lexington: The University Press of Kentucky, 1995).

odd pastiche," not really a work of history as Morse's later books would be.[66] The volume includes information like a sketch of Qing bureaucracy, the state of domestic and international trade in China, and the legal system as it applied to foreigners. It reads like a helpful introduction to China rather than an analytical work of history. This is rather understandable given that it was published in 1908, when Morse had yet to leave the Maritime Customs. At that time, Morse was still in his last post as the statistical secretary in Shanghai. His main task was to oversee the compilation and publication of a wide variety of economic information about China. It was a position which suited the fastidious administrator who had carefully vetted the responses to the RAS survey on local currencies, weights, and measures, and added his own annotations noting possible errors or inconsistencies.[67]

Morse's criticism of weights and measures in *Trade and Administration* overlapped with points that Martin and Smith had made earlier. Like Martin, he acknowledged the existence of an orderly Chinese system of measurement, but decried the pandemonium in the practice of measurement. He declared that "The state of the weights and measures is… chaos itself."[68] The problem was that the Chinese seemed to disregard standards and systems of measurement. Even though a theoretical decimal system existed, "the Chinese would not be Chinese if, in applying this theory to practice, they did not make some differences."[69] In this work, Morse did not delve fully into the details of China's metrological mess, but relied on several examples to condemn the "the mental attitude of those on whom it is sought to impose uniformity."[70] Compared to Martin and Smith, Morse had more data from his personal participation in the RAS survey in

[66] Ibid., 216.
[67] Morse, "Abstract of Information," 86, 104.
[68] Hosea Ballou Morse, *The Trade and Administration of the Chinese Empire* (London: Longmans, Green and Co., 1908), 170.
[69] Ibid., 170.
[70] Ibid., 174.

Pakhoi (Beihai), where he was based at that time, his compilation of the survey's results, and his professional activities in the Customs' department of statistics. But he reached the same kind of conclusion that measurement was a mess and agreed that it was an indictment of Chinese society. He concluded with pessimism about the possibility of imposing a singular metrological order in China: "it must be remembered that China is not one country, it is a dozen; it is a continent, with the population and the diversity of a continent, with the inborn habit of centuries to stereotype the minds of the people, and with the natural stubbornness of an old civilisation to resist all change."[71]

According to Fairbank, Morse's comments on weights and measures, and currency made the effective case for standardization among foreigners.[72] Morse's work continued to be circulated and referenced in the following years. The very next year, 1909, the *North-China Herald* printed a dispatch from an unnamed correspondent on the units of measurement extant in the southwestern China. The author had apparently been collecting information about units of measurement in the southwestern provinces of Yunnan and Sichuan for many years and included original data from these regions. However, the report lifted, fractured and recombined chunks of Morse's writing about measurement, and copied almost all of Morse's data on weights and measures in places like Canton, Shanghai, Nanjing, and Soochow (Suzhou) without attribution.[73] Second and third editions of *Trade and Administration* appeared in 1913 and 1921, and Morse's comments within this volume continued to be read and treated as authoritative.[74] In 1917, *Millard's Review of the Far East* printed Morse's chapter on weights and measures in China in

[71] Ibid.
[72] Fairbank, Coolidge, Smith, *H.B. Morse*, 178.
[73] "Chinese Weights and Measures," *The North-China Herald and Supreme Court & Consular Gazette*, Nov 6, 1909, 313.
[74] Fairbank, Coolidge, Smith, *H.B. Morse*, 178, 218.

its entirety. In 1927, when the Russian scholar A.V. Marakeuff produced a monograph on the topic, it was still Morse's work which was used to assess the accuracy of its data.[75]

Between the 1870s and 1900s, a consensus about measurement in China emerged among a certain stratum of foreigners. At least some of the foreigners who paid attention to weights and measures recognized that China had an orderly system of measurement. Conscientious surveyors also acknowledged the existence of organized practices to enforce local standards. Writing from Zhejiang province in response to the RAS circular of 1889, Dr. Macgowan noted that local residents of cities in Zhejiang province were scrupulous when it came to "the all-important matter of rice measuring." In smaller cities like Wenzhou, "so well do the consumers of this comestible know how many bowls of rice a given measure should contain, that the least fraud would be detected and the dealer lose custom—a matter that never happens."[76] In the larger city of Ningbo, uniformity of measures for rice was enforced by the guild of rice merchants. The trade association required its members to submit the measures used to sell rice for inspection every fortnight. Dr. Macgowan further noted that at these sessions "[care] is taken to provide against the expansion and shrinkage which is consequent on the hygroscopic condition of the season, chunam being added or removed from the corners of the measure so as to adapt it to atmospheric vicissitudes."[77] Even Arthur Smith had to concede that the Chinese seemed to have a shared understanding of how to measure the distances of journeys although he found the practice of changing the definition of the *li* fantastical. He found to his astonishment that those he surveyed were unanimous and consistent about the lengths of particular journeys.[78]

[75] "Two New Books Out Deal With Commerce Here," *The China Press*, Jun 25, 1927, 12.
[76] Morse, "Abstract of Information," 54.
[77] Ibid., 54-55.
[78] Smith, *Chinese Characteristics*, 81.

Despite all the order they could or could not see, foreigners unanimously decried China as a metrological mess. What they meant was that China should have and enforce only one system of measurement. Against this yardstick, a situation where different trade guilds enforced their own definitions of the *jin* and where people shared informal customs for using the *li* was chaos. In Arthur Smith's words, "That there is *some* basis for estimates of distances, we do not deny, but what we do deny is that these estimates or measurements are either accurate or uniform."[79] The assumption that metrological order *must* be singular led inescapably to the assessment of chaos even when careful investigators could fathom the order within local or informal systems of measurement. (Not everyone could. One surveyor in Guangdong wrote that "No one seems to know the area of the Mow [*mu*], and it is said to vary not only in different districts, but to be variously reckoned in fields contiguous to each other."[80] The central importance of land in China's rural economy and society makes the absence of any standard or order in its measurement improbable.) And it was the idea of chaos which gained the most currency. The careful caveats like the one Dr. Macgowan sent in were relegated to the notes after the foreword and summaries which laid out the varying definitions of units in China. The more measured evaluation of China's metrological system and landscape written by W.A.P Martin was less popularly read than Smith's account—where the idea that China has a theoretical system of measurement receives no mention at all.

The conviction that there should only be one metrological order across China explains why foreigners were repeatedly perplexed by Chinese nonchalance towards the state of measurement in the empire. Reverend Martin even-handedly noted that many western countries had only recently imposed common systems of measurement throughout their territories. From

[79] Ibid., 80.
[80] Morse, "Abstract of Information," 100.

this perspective, China was behind the west, but not very far behind. However, there was "one important difference" between western societies and China. While westerners were "not content" with non-standardized units of measurement, the Chinese were "apathetic."[81] Arthur Smith also mocked how the Chinese seemed to bear the metrological mess as matter-of-course, or even reveled in it. "The existence of a double standard of any kind, which is often so keen an annoyance to an Occidental, is an equally keen joy to the Chinese. Two kinds of cash, two kinds of weights, two kinds of measures, these seem to him *natural and normal*, and by no means open to objection."[82] H.B. Morse was particularly appalled by the fact that Chinese businessmen showed no interest in the matter of non-standardized measures given how this directly affected their activities. His foreword to the RAS survey on weights and measures in China in 1900 noted that the "apathy of the mercantile residents in China on this subject, which so closely affects their interests, is remarkable, not one paper having been received from any member of that influential body."[83]

WHICH MEASURE FOR CHINA?

In the final decade of the Qing, it was no longer true that the Chinese did not care about the state of measurement in the empire. Chinese reformers came to share the perception that varying systems of measurement were a problem and that the throne should move to enforce a single system of measurement. They painted a picture of measurement in China which bore a strong resemblance to that by Morse: China has a system of measurement, but in reality units of measurement varied across space and sector. In coastal Zhenhai county (Zhejiang province; now Zhenhai district, part of Ningbo town), people used four kinds of rulers. In addition to the Qing's

[81] Martin, "The Metric System for China," 57.
[82] Smith, *Chinese Characteristics*, 78. (emphasis mine)
[83] Morse, "Abstract of Information," 48-9.

yingzao ruler (*yingzao chi*), those working with wood and stone used the *luban* ruler (*luban chi*, named after the mythical originator of carpentry Lu Ban); people sold and bought textiles using the *cai chi*; and, anything to do with industrial machinery was measured with the *ying chi*, the English ruler.[84] In Sichuan province, provincial authorities had verified the standards for *tianping* scales in the thirty-third year of the reign of the Guangxu emperor (r. 1875-1908) (1904) and the province's population was limited to using only that scale and the standardized weights. However, provincial authorities did not regulate instruments of capacity and people used a variety of cups or dippers to buy and sell goods like grain and oil in Sichuan.[85] This was typical throughout China—in any one place, people lived with multiple local metrological orders, some of which were more strictly enforced and others which were loosely shared.

Around the turn of the twentieth century, reformers, most notably trade guilds and groups advocating the development of commerce, began petitioning the Qing to standardize units of measurement.[86] Just then, the Qing court was embarking on a rash of reforms, the New Policies (1901-1911), in the wake of the disastrous debacle of the intervention of the Eight Nation Army against the Boxer Uprising (1899-1900). The court's ambitious agenda to survive in the twentieth century included a plan to develop new security forces modeled on Yuan Shikai's Beiyang Army, moves to establish a new school system in provinces, counties, and prefectures based on Japan's national education system, and a plan to transform the imperial ministries into modern government departments. In 1908, the Qing court even took the drastic step of announcing a plan to move towards constitutional government. The court's decision on the

[84] "Zhenxiang er xian zaosong duliangheng biao" [Two counties Zhen Xiang draft and submit summary of weights and measures], *Xinwenbao*, Feb 14, 1908.
[85] "Huixian xiaoyu duliangheng banfa baihua gaoshi" [Merchant] Association Leader Explains Plan on Weights and Measures in baihua], *Sichuan guanbao* 16 (1909).
[86] "Shuntianfuyin shenzou sheli duliangheng bing zaozhi guanju zhe" [Petition to Establish an Agency for Weights and Measures and the Manufacture of Paper], *Beijing zazhi* 1 (1904): 25-27.

matter of weights and measures, also announced in 1908, appears especially conservative in light of the dramatic measures it was taking in other areas. Although the Qing court had received replicas of the meter and kilogram standards housed in France that year, the Qing chose to renew China's commitment to units of measurement which had been set during the reign of the Kangxi Emperor: the *yingzao chi*, a basic unit of length; the *kuping jin* as the basic unit of weight, and the *cao hu* as the basic unit of volume.[87]

This response to the call to standardize units of measurement from the Qing court was anemic at best. It only took shape after years of appeals and there was no clear plan for implementation. One gazette in Sichuan announced that local authorities were supposed to begin by standardizing weights and measures at the village level. This effort in villages and towns was supposed to ripple out into a single set of standards at the county level some years later. The replication of this process at the provincial and regional levels was supposed to achieve the end goal of unifying China under the Qing metrological system.[88] Another notice faintly endorsed these practices but exhorted authorities to take steps as appropriate to local contexts.[89] At the same time, newspapers reported that imperial authorities were facing trouble manufacturing measuring equipment because of the variation in the size and design of instruments people were familiar with across China.[90] By the time history overtook the Qing, central authorities seemed to be still treading water on the brink of enforcement. They were still in the process of collecting

[87] "Yuchi suding dulianghengzhi" [Directive to Confirm Weights and Measures], *Xinwenbao*, Oct 10, 1907; Weisun Du, "Bijiao zhongfa dulianghengshuotie shang huiyi zhengwuchu" [Memorandum comparing Chinese and French systems of measurement submitted to the Bureau of Government Affairs], *Dongfang zazhi* [The Eastern Miscellany] 5, vol. 7 (1908): 33-36.
[88] "Huixian xiaoyu dulianghengbanfa baihua gaoshi" [[Merchant] Association Leader Explains Plan on Weights and Measures in baihua], *Sichuan guanbao* 16 (1909).
[89] "Wei zisong huayi dulianghengyuanzou ji tubiao zhangcheng bing xi jiang ruhe chouban zhichu xianxing jianfu shi" [Conveying original memorial, charts and rules for metrological standardization and advance plans for implementation], *Shangwu guanbao* 31 (1908): 10-11.
[90] "Zi shang zizao dulianghengbanfa" Plan for commercial production of weights and measures], *Shibao*, Mar 11, 1909, 2.

information about weights and measures, and the types of equipment used in different parts of China.

Notably, those who had pushed this onto the Qing were businessmen— the sorts of people whom foreigners felt were indifferent to non-standardized weights and measures. It was merchant associations which petitioned the throne to standardize units of measurement and commercial groups which conducted independent surveys of weights and measures across China.[91] Merchants also took the lead in championing the reform after it was announced.[92] In this period, writing about measurement also appeared predominantly in commercial gazettes and periodicals. Understandably, an idea which recurred in these articles was that standardized weights and measures would be an essential foundation (*jichu*) for boosting commerce. One particularly enthusiastic advocate proclaimed that the world was a commercial battlefield; standardized units of measurement would be an invaluable weapon to enhance China's arsenal and its ability to survive in this environment.[93]

Chinese reformers also kept an eye on metrological developments elsewhere. They singled out the metric system for special praise. The metric system's global popularity was a major reason for Chinese admiration. Chinese writers admired the metric system's international spread beyond its country of origin, France. Writers also usually highlighted that it was the most convenient (*bianli*) system of measurement. The fact that it was entirely decimal (*shijn*) made calculations a cinch. In this respect, the metric system was very favorably compared to British units of measurement which flitted between different scales. For instance, there are twelve inches

[91] "Duliangheng bijiao biao" [Comparison of Weights and Measures], *Shibao*, Oct 2, 1904, 1-2; "Qing huayi duliangheng" [Please standardize weights and measures], *Xinwenbao*, Jan 27, 1907.
[92] "Huixian xiaoyu duliangheng banfa baihua gaoshi" [Merchant] Association Leader Explains Plan on Weights and Measures in baihua], *Sichuan guanbao* 16 (1909).
[93] "Wanguo duliangheng zhidu gaishuo" [Overview of international spread of metric system], *Nanyang shangwu bao* 23 (1907): 1-5; "Jiri duliangheng huayi zhifa" [The Method for Standardizing Weights and Measures], *Guangyi congbao* 146 (1907): 1-2.

in a foot but sixteen ounces in a pound. One rabid metric fan claimed that the metric was unlike any other system of measurement. While other units of measurement were derived from arbitrary and changeable man-made (*renzao*) standards, the meter was based on the length of a meridian—a natural (*tianzao*) standard. The latter was intrinsically superior because it was invariant and hence, suitable as a cornerstone for an entire system of units of measurement. This advantage explained the metric's spread in the military and the practice of medicine even in countries which had not embraced the metric system.[94] For many of the Chinese men who paid attention to global metrology, there was something special about the metric system.

But in the 1900s, there were also those who were not swept up in the metric frenzy. After all, the 1908 Qing reform set China on a course to return to a system of measurement which had been made in China, not one which had been born in France. A vocal minority had reservations about the metric system. In 1906, one writer, Ye Zaiyang, attacked the basis of the meter, arguing that the meridian was an inappropriate foundation for an entire system of measurement. The French had favored the meridian passing through Paris over a multitude of alternatives of varying lengths. Moreover, they had measured their chosen meridian imprecisely. He proposed basing the basic unit of measurement for length on the equator instead. His formula for doing so produced a unit which uncoincidentally lined up with the Qing *yingzao chi*.[95] This article was a fairly technical essay which delved into and took aim at the making of the meter, and proposed an alternative with Chinese roots. Articles of this variety would recur in the following decades. The argument that China should embrace the metric system became mainstream, but the majority opinion was always dogged by a minority camp which saw the metric system as imperfect.

[94] Xia An, "Faguo duliangheng shuo" [French Weights and Measures], *Nonggongshang bao* 24 (1908): 49-52.
[95] Zaiyang Ye, "Duliangheng xinyi" [New Commentary on Weights and Measures], *Xinwenbao*, Sept 21, 1906.

Others noted that metric units were very different from Chinese ones, and pushed for a gentler introduction of the meter, the liter, and the kilogram to China. One reformer suggested that Japan's measured approach to the metric system might be a good model for China. Japan had officially joined the international convention for the metric, but the standards that it enforced for its people were not taken lock, stock and barrel from Paris. For example, the basic unit for measuring length in Japan was three-tenths of the French meter. The county's official basic unit for weight was likewise a fraction of the standard kilogram preserved in France. Moreover, the Japanese metrological regime accommodated certain exceptions to the new standards. For example, those working in textiles were still allowed to use their *jinchi* with units that were unrelated to metric ones.[96]

After the 1911 Revolution, the problem of weights and measures fell to the Qing's Republican successor in Beijing. Between 1911 and 1912, the government considered a proposal which shifted the goalposts on metrological reform.[97] The proposal began by arguing that Chinese units of measurement should go the way of dynastic rule. It made direct, frontal attacks on China's official system of measurement which the foreigners had not articulated thus far. The proposal explained that China's units of measurement were flawed because they were based on grains. This was problematic because the length, breadth, and weight of grains varied across time and space, and even from grain to grain. This unreliability meant that there was no firm standard for a unit like the Qing *yingzao chi* , or the rulers which had been set using similar procedures in preceding dynasties. Second, metrological reformers faulted the Chinese system of measurement for being too complicated for easy, convenient use in daily life. The proposal pointedly noted

[96] "Jiri duliangheng huayi zhifa" [The Method for Standardizing Weights and Measures], 1-2.
[97] "Gongshangbu gongwusi niding gaige duliangheng zhidu shoumingshu" [Ministry of Industry and Commerce Gongwu Department Proposal to Reform System of Weights and Measures], file 1001(2)/1774, SHAC.

that Chinese units of measurement were not uniformly decimal. The proposal's authors also criticized the lack of direct and clear relationships between different units of measurement.

Since China's system of measurement was fundamentally flawed, reformers shopped for a new possibility from an international menu of options. The proposal compared the systems of measurement which were on the books in places like Britain, France, Russia, and Japan. The metric system came out on top in a very measurable way: the proposal listed the growing number of countries which had already gone metric (twenty-four to date) or allowed its coexistence with local units of measurement (twelve).[98] These numbers made the unassailable case that the metric system was far and away the most widely used system in the world.

The proposal also offered a list of reasons for China to jump on the metric bandwagon. Broadly speaking, the several reasons can be divided into two types. The first category praised aspects of the metric system. The authors highlighted that the meter was based on a true (unchanging) foundation, namely the meridian passing through Paris. The standard meter was absolutely accurate, as verified by international experts. In adopting the metric system, China would be benefitting from the scientific expertise which had been poured into the creation of this system. Another major strength of the metric system was that it was entirely decimal. The blanket adherence to the rule of ten—no matter which dimension one was measuring, or whether one was scaling units up or down—made calculation exceedingly simple. The second category of arguments stressed that metric units would facilitate China's interface with the world. The most modest of these claims pointed out that adopting units which were already so widely used or understood around the world would make it easier to sell Chinese goods in the international marketplace and to translate scientific literature into Chinese. More exaggeratedly, the authors

[98] Ibid., 13-17.

claimed that going metric was the first step towards alleviating poverty in China through industrialization.[99] The metric was the clear choice for China, both for what it was and what it could do for China.

By then, metric fever had clearly made its way into official thinking. There was widespread support for the proposal when it was circulated to various ministries for comment. The ministries overseeing agriculture and forestry, finance, education, foreign affairs, transport, and internal affairs, as well as China's armed forces all supported the overall proposition for China to go metric.[100] Even the anticipated objections to metrication laid out by the proposal's authors did not faze government officials. (The proposal had forecast that detractors might point out that it would be extremely difficult to shift the definition of the *chi* or the *jin* given how deeply ingrained these were, that conservatives would champion retaining Chinese units of measurement to preserve China's "national essence" (*guocui*) and that it would be tedious to change the units of measurement codified in China's international treaties.)[101] The responses to the proposal raised objections, but not the kind which opposed metrication. The Ministry of Foreign Affairs registered reservations about the short timeline for full metrication while a few other ministries offered alternatives to the proposed system of nomenclature for metric units.[102]

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[99] Ibid., 29-30.

[100] "Lujunbu duliangheng shuotie" [Army's response to weights and measures proposal], file 1001(2)/1774, SHAC; "Nonglinbu han" [Ministry of Agriculture and Forestry correspondence], file 1001(2)/1774, SHAC; "Caizhengbu qianzhu yitiao" [A note from the Ministry of Finance], file 1001(2)/1774, SHAC; "Jiaoyubu han" [Ministry of Education correspondence], file 1001(2)/1774, SHAC; "Waijiaobu shuotie" [Ministry of Foreign Affairs response], file 1001(2)/1774, SHAC; "Neiwubu han" [Ministry of Interior Affairs correspondence], file 1001(2)/1774, SHAC; "Haijunbu han" [Navy correspondence], file 1001(2)/1774, SHAC; "Sifabu han" [Ministry of Law correspondence], file 1001(2)/1774, SHAC.

[101] "Gongshangbu gongwusi niding gaige duliangheng zhidu shoumingshu" [Ministry of Industry and Commerce Gongwu Department Proposal to Reform System of Weights and Measures], file 1001(2)/1774, SHAC.

[102] "Waijiaobu shuotie" [Ministry of Foreign Affairs response], file 1001(2)/1774, SHAC; "Lujunbu duliangheng shuotie" [Army's response to weights and measures proposal], file 1001(2)/1774, SHAC; "Nonglinbu han" [Ministry of Agriculture and Forestry correspondence], file 1001(2)/1774, SHAC; "Caizhengbu qianzhu yitiao" [A note from the Ministry of Finance], file 1001(2)/1774, SHAC; "Jiaoyubu han" [Ministry of Education correspondence], file 1001(2)/1774, SHAC.

By 1912, the government seemed fully on board with metrication. But the Beijing government only took half a step towards metrication. The system announced in 1915 recognized two systems of measurement in China. The Qing *yingzao zhi* survived, and the metric was endorsed as China's second legal system of measurement. This metrological system recognized the desirability of embracing the metric system, but also the difficulty of doing so. Thus, organizations or people who could use metric units were allowed to do so, but in all other cases, the government pursued the easier objective of getting people to use a common set of units of measurement which they had at least some level of familiarity with, namely the official system of measurement under the Qing. Getting most of China to use one system of measurement, even if it was not the metric system, was supposed to set the stage for transitioning China to the metric system.

Studies of metrological reform in Republican China note that little headway was made in enforcing this system given the political instability of the 1910s and 1920s. Incessant struggles between different warlords with regional bases of power was inconducive for metrological reform. The Beijing government managed to establish a factory for manufacturing standards and measuring equipment in the capital, but enforced the legal system of measurement only in Beijing and nearby Shanxi province.[103] In these narratives, the next milestone in China's modern metrological history is July 1928 when the GMD regime in Nanjing set their sights squarely on the metric system.

This timeline misses the ferment over weights and measures which occurred within China's scientific community in the meantime. When scientists and engineers came to the negotiating table with an alternative to the metric in 1928, they were presenting results from

[103] Guan et al., *Zhongguo jinxiandai jiliang shigao* [A Draft of the History of Modern and Contemporary Metrology in China], 61-77.

years of work. Some of the Chinese men who had earned bachelor's and graduate degrees overseas in the first few decades of the twentieth century had been paying attention to metrological matters for some time. Many of those who wrote about measurement published in *Kexue* (*Science*), the journal of the Science Society of China (*Zhongguo kexue she*). The society was established in Ithaca, New York, in 1914 by several members of the first cohorts of Chinese students who received scholarships drawn from the return of America's share of Boxer indemnity funds to study science and technology in the United States.[104] One of its founding members was Hu Mingfu, one of the three Hu brothers (*hushi sanjie*) who are lionized in the history of science in Republican China.[105] The society's founders saw themselves as pioneers, nurturing the growth of modern science from its infancy in China. *Kexue* was not meant to be an exclusive platform for scientists or researchers. Its inaugural issue contained essays on gravity and the silk industry in Meiji Japan, and shorter articles explaining how to tell the age of trees or why cats always landed on their feet. The introductory remarks from its inaugural issue clearly stated the society's goal of conveying scientific knowledge to a general audience. The team behind the journal even invited their readers to submit questions which piqued their interest for a regular section dedicated to answering such queries.[106]

With this objective in mind, *Kexue*'s editors noted that it was problematic that there was no settled consensus for many scientific terms in the Chinese language.[107] In fact, these terms would only be painstaking hammered out by scientists, educators and publishers between the late 1910s and the 1920s. Some of the members of the Science Society of China, including Hu

[104] Zuoyue Wang, "Saving China through Science: The Science Society of China, Scientific Nationalism, and Civil Society in Republican China," *Osiris*, 2nd series, vol. 17 (2002), 291.
[105] Xinguo Cheng, "Hushi sanjie yu datong" [The three outstanding Hu brothers and Datong], *Shiji*, Jan 15, 2003, 34-36.
[106] "Liyan" [Introductory remarks], *Kexue* [Science] 1, no. 1 (1915): 1-2.
[107] Ibid.

Mingfu and his brother Hu Gangfu, participated in the deliberations of the Joint Terminology Committee between 1915 and 1927.[108] But in 1915, *Kexue*'s editors settled for a stopgap measure of using the most common terms, and switching to standardized Chinese terms as and when they were established. The team behind *Kexue* also made another editorial decision which has been eyebrow-raising for modern historians— they decided on horizontal typesetting. They defended this controversial deviation from conventional vertical typesetting, and the decision to use punctuation, as necessary for clearly conveying scientific information, including equations with numbers and symbols.[109]

Kexue's second issue carried the journal's first article dedicated to weights and measures. It was a statement of the Science Society of China's position on the metrological reform recently announced by the Beijing government.[110] The Society's position reflected its members' concerns about the unsettled nature of the basic conventions necessary for disseminating scientific knowledge in China. The Chinese students praised their government for embracing the metric system, the most widely-used (*tongxing*) system around the world. This was a notable breakthrough compared to the late Qing insistence on returning to an "ancestral" system of measurement (*zuzhi*). They also celebrated the fact that the announcement defining Chinese units in terms of metric ones gave the former accurate standards (*biaozhun*) for the first time. However, they were troubled by certain aspects of the official scheme. Was the Beijing government steering China towards full metrication? This was not explicitly stated as an objective and official policy allowed people to keep using either of the two systems. Disturbingly, the government had directed all ministries, except the Ministry of Education, to use

[108] Luesink, "Dissecting Modernity," 110.
[109] "Liyan" [Introductory remarks], 1-2.
[110] "Quandu xinming shangque" [Discussion on New Nomenclature for Units of Measurement], *Kexue* 1, no. 2 (1915): 123-29.

the Qing *yingzao zhi*. The society's members pointed out that if China's old measures were meant to be transitory, they were too dissimilar to metric units to serve this role.

Additionally, the Chinese students were concerned about the nomenclature the government had laid out to refer to metric units. The Beijing government had specified that the meter was to be called *xin chi*, meaning the new *chi*; the kilogram was labeled *xin jin*, the new *jin*, and the liter was called *xin sheng*, to denote that it was the new *sheng*. Each of these new labels merely prefixed existing terms for units of measurement with "*xin*" (new). The students were worried that people would not understand these newfangled terms since the *chi*, *jin*, and *sheng* used to have such different meanings. If the *jin* was equal to sixteen *liang*, would people understand that the new *jin* was equal to a thousand grams? Was the new *chi* (meter) new in the same way that the new *jin* (kilogram) was new? It seemed confusing to graft an entirely different meaning onto an existing metrological term with a prefix. Their second concern was that the designated set of terms did not cater to scientific research. The repetition of terms like *xin fen* across different dimensions was problematic. *Xin fen* could refer either to a centimeter (one hundredth of a meter) or a gram (one thousandth of a kilogram). The statement explained that this repetition was thorny for scientists because "units of length and mass are often used simultaneously in physics and other sciences." The article concluded by stating that if the government wanted experts to use the official system of measurement in research, it was imperative for these concerns over nomenclature to be addressed. The society also appended a proposed alternative system of nomenclature which clearly marked metric units as different by

transliterating the names of metric units in western languages. The meter would be *mi*, the gram would be *ke*, and the liter would be called *lite*.[111] [112]

By 1918, the key members of the Science Society had returned to China, and the center of gravity for the society and its journal shifted to the Utopia School (*Datong xueyuan*) in Shanghai, a college established by the eldest Hu brother Hu Dunfu after he resigned from Tsinghua University to protest American imperialist control of the institution.[113] Some scientists in Shanghai had started to have deeper misgivings about China's slide towards the metric system. They did not object to how the government was introducing metric units but the proposition that China should do so at all. The hunt for a better system of measurement began on the campus of Aurora University (*Zhendan Daxue*). The university had been founded in 1903 by French Jesuits in collaboration with Ma Xiangbo, an ex-priest and a former Qing official.[114] P. Vittrant (transliterated as費德朗), a French scientist and head of the department of physics, was annoyed with the difficulty of studying electromagnetic phenomena using units derived from the metric system.[115] He was grappling with the unsettled issue of how to deploy metric units in scientific research in his field.

Although electricity was in vogue in eighteenth-century Europe, people tended to focus on the *spectacle* of electricity. Electricians (a term which used to refer to people who dabbled with a certain type of yet-unexplained phenomena) regaled audiences with performances which

[111] Ibid.
[112] The issues raised in this early *Kexue* article would re-surface as the center of a heated dispute about the national system of measurement between the GMD government and China's scientific community in 1934-35. I examine this dispute in chapter four, Scientists and the Scientific System of Measurement.
[113] Xinguo Cheng, "Hushi sanjie yu datong," *Shiji*, Jan 15,2003, 34.
[114] Cindy Yik-yi Chu, "The Catholic Church in China in the First Half of the Twentieth Century: The Establishment of Zhendan University and Furen University," in *Eurasian Encounters: Museums, Missions, Modernities*, eds. Carolien Stolte, Yoshiyuki Kikuchi (Amsterdam: Amsterdam University Press, 2017), 162.
[115] Jinyu Liu, Jingyong Chen, "Niding zhonghuaminguo quandu danweizhi yijianshu [Opinion on Proposal to Set the Metrological System of the Republic of China]," *Gongcheng: Zhongguo gongcheng xuehui huikan* [The Journal of the Chinese Engineering Society] 3, no. 4 (1928): 324.

featured live boys suspended from silk wires attracting objects like feathers or even running a current through a line of live people holding hands.[116] Natural philosophers' approaches towards electricity were not significantly different from those of the performers and audiences in salons. In the 1770s, the eccentric British scholar Henry Cavendish used pieces of thick leather to create an artificial torpedo, a species of electric rays, to demonstrate that such animals were generating the electric currents which allowed them to stun their prey underwater. Writing about electricity emphasized its, well, electrifying effects.[117] In the 1780s, the French engineer Charles Coulomb pioneered a new *quantitative* approach towards electricity by using a torsion balance— an apparatus of his own invention— to demonstrate that "electrical effects can be described by a Newtonian square law."[118] Coulomb studied electricity as a force which he could measure. His endorsement of a 1759 treatise by the German theoretician Franz Æpinus also helped to found a mathematical and experimental approach towards electricity in France.[119] In the nineteenth century, the question became which units to use to measure electromagnetic forces. In 1833, Carl Friedrich Gauss demonstrated that all electromagnetic quantities could be expressed using units derived from three basic units of length, mass, and time. Gauss and W. Weber selected the millimeter, milligram, and second. However, it was Lord Kelvin and James Clerk Maxwell's system, based on the centimeter, the gram, and the second (CGS) which became the more widely used system for measuring electrical energy after the 1860s. Unfortunately, the CGS system did not settle the question of how electromagnetic forces should be measured. The snag was that it was used to develop two separate and inconsistent sets of units for measuring electricity. These

[116] Patricia Fara, *An Entertainment for Angels: Electricity in the Enlightenment* (London: Icon Books Ltd, 2017), 56-7.
[117] Ibid., 139-44.
[118] Ibid., 123, 125-28.
[119] Ibid., 125-28.

were the electrostatic (es) system and the electromagnetic (em) system. In the late nineteenth century, the em system formed the basis for defining a set of practical units to meet the needs of electrical engineers. These units— the ohm, ampere, and volt— were integer multiples of em units and were endorsed at meetings of the International Electrical Congress in 1889, 1893 and 1908.[120]

By the early twentieth century then, there were well-defined and widely-used international conventions for measuring electrical energy. But scientists like Vittrant were dissatisfied because "there were two mutually inconsistent CGS systems; es and em."[121] Vittrant's collaborator Liu Jinyu, an engineer and also a faculty member at Aurora University, suggested that systems of measurement in China's past might offer a solution to Vittrant's problems. By 1921, Vittrant was gushing about an historical system of measurement in *The Eastern Miscellany* (*Dongfang zazhi*).[122] Vittrant praised the Chinese system of measurement for being based on an accurate measurement of the meridian though he did not offer further details of when or how such a measurement had taken place. He applauded its complete decimalisation. While adherents of the metric still had to make exceptions for the measurement of time and angles, the Chinese had figured out how to apply the rule of ten uniformly to all aspects of reality centuries ago.[123] Conveniently, Chinese units of measurement would make it simpler for Vittrant to conduct his research. The combination of these advantages made it obvious to him that China should embrace this domestic system rather than the metric.

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[120] Ludwik Kowalski, "A Short History of the SI Units in Electricity," *The Physics Teacher* 24, 97 (1986): 97-99.
[121] Ibid., 98.
[122] P. Vittrant, "Lun zhongguo duliangheng zhi zhi danwei" [On China's Weights and Measures], *Dongfang zazhi* 18, no. 24 (1921): 43-49.
[123] Vittrant's understanding of Chinese systems of measurement is suspect. Everyone else who wrote about historical units of measurement in China described a system based on grains and the length or pitch of courtly ceremonial pipes like the *huangzhong*. Additionally, everyone else praised the high degree of, not the complete, decimalization in China's theoretical system of measurement.

In 1923, Liu took the lead in developing this project in *Kexue*. After reiterating the inadequacies of the metric system which Vittrant had identified, Liu clarified that they did not see the metric system as utterly without merit. He acknowledged that its basis (*genju*), principles (*yuanze*), and formula (*gongshi*) cohered with scientific principle. However, he claimed that he could harvest these strengths and eliminate some of the flaws in the metric system by lightly modifying the Chinese system of measurement, thereby producing a system superior to the metric. Vittrant and Liu proposed three fundamental units to anchor their proposed Chinese system of measurement (*Zhonghua danwei zhi*). The *chi* was to be the basic unit of length, measuring 33.33956 centimeters, or, in practice, a third of the meter (100 centimeters).[124] Liu and Vittrant proposed a unit called the *tizhi danwei*, or *zhidan* for short, as the basic unit for mass. A *tizhi danwei* would be equal to the mass of one cubic *chi* of water. Finally, they proposed the *hua miao*, the Chinese second, as the basic unit for measuring time. Each day was to be divided into twelve *shi*; each *shi* into ten *ke*; each *ke* into ten *fen*; and each *fen* into 100 *miao*. After the publication of this article, Liu commissioned the factory established by the Beijing government to create two standards, one for the standard chi (*biaozhun chi*)and a set of scales for the proposed Chinese system of measurement.

Liu Jinyu stayed with the problem of measurement and published a modified proposal four years later, just as the GMD government was tackling metrological reform.[125] After acknowledging that he and Vittrant had been too keen to revert to a bygone system of measurement, he adjusted the basic units he was prescribing for China. In the most polished of his publications on the topic, Liu listed the core principles behind his years-long search for a

[124] Note: these two lengths are not identical; Liu acknowledges this by writing that "in effect," the Chinese *chi* would be a third of the meter.
[125] Liu, Chen, "Niding zhonghua minguo quandu danweizhi yijianshu" [Opinion on Proposal to Set China's Metrological System], 320-27.

better metrological alternative for China. Liu emphasized that China's system of weights and measures must have systematic order. Specifically, it should be entirely decimal. Second, he insisted that China must have only one system of measurement for all activities, including science, and industry and commerce. This included supporting the quantitative study of electromagnetism. Lastly, Liu now stressed that new units of measurement must be close to existing systems of measurement. By this he meant the units of measurement used in China, Britain, and the United States of America. Liu had noticed that the basic units of the metric system, the meter and the kilogram, were not exactly tailor-made for everyday life. After all, the meter was just an arbitrary fraction of the length of the meridian running through Paris—a measurement which Liu noted was now outdated. In contrast, approximately nine billion people—the combined population of Britain and its empire, the US, and China—had long used units of measurement which had more in common with each other than the metric. The various *chi*s of China, ranging from a mere twenty-two centimeters to a maximum of forty-five centimeters, were closer to the English foot (30.48 centimeters) than to the meter (100 centimeters). Likewise, the pound (450 grams) could be thrown into the mix of different Chinese *jin*s, but these were quite unlike the kilogram (1,000 grams). Liu was sure that these units owed their longevity to how fitting they were for the kinds of measurement most people carried out in their everyday lives. It was so important to him to cater to these needs that he proposed calling the new system of measurement he was developing the ABC system, indicating its inspiration from the metrological practices of America, Britain, and China.

The British system of measurement, the metric system, and China's old *yingzao* system all failed to meet these three criteria. British inches and pounces were deeply embedded in everyday life, but were absent in science laboratories, textbooks and journals. Like many of his

compatriots, Liu also inveighed against the fact that the British system of measurement was not decimal. This complicated calculation. The metric system also failed on two counts—its basic units were unsuitable for general use and scientific research. The old Qing *yingzao* system had "no basis in scientific evidence." It also did not possess the kind of order which Liu was looking for. The inadequacy of these top three existing metrological models led Liu to propose a new system of measurement. His proposed fundamental units were the *zheng chi*, equal to 32.689016 centimeters; the *zheng liang*, equal to 34.9296 grams; and, a new unit for measuring time, the *baifen miao*. Liu urged the GMD government to endorse his proposal, arguing that setting the right kinds of standards for China was congruous with a revolutionary spirit of independence and the spirit of progress in science.[126]

This proposal was warmly received by the coterie of scientists and engineers in China, including Hu Gangfu. Liu had discussed the design of his final proposal with Hu Gangfu, the third of the Hu brothers. Hu Gangfu was part of the first cohort of Chinese students awarded Boxer scholarships to pursue higher education in the US in 1909, and became the third Chinese individual to receive a Ph.D. in physics (from Harvard) in 1918. Hu dedicated his career to scientific education (rather than research) and is credited with introducing and promoting practical experiments as an essential component of training in the sciences at the tertiary level.[127] (The hagiographic accounts of his life credit him with establishing the first scientific laboratory in China in 1918. In 1988, the Chinese Physical Society established the Hu Gangfu Award to recognize outstanding skill in experiments.)[128] Liu Jinyu reports that it was Hu who insisted that

[126] Ibid.
[127] We will meet one of Hu's most prominent students, Yan Jici, in chapter four, Scientists and the Scientific System of Measurement. Yan was an active participant in the 1934-35 dispute over China's system of measurement between the government and scientists.
[128] Ruanliang Ling, "Zhongguo wulixue qianbei—Hu Gangfu" [Pioneer of physics in China—Hu Gangfu], *Daxue wuli* 28, no. 4 (2009): 43-51.

China's new national system of measurement must better accommodate electromagnetic forces than the metric system. It was also Hu, the father of modern physics in China, who amplified the ambitions of his peers by christening the new system the *Yuanren zhi*, or the Système Homo. To Hu, they were setting not just China but the world on the right metrological track. Chen Jingyong, an engineer, was likewise inspired by the broader significance of the project. He dubbed the new units of measurement the *zheng chi* and the *zheng liang*, explaining that these terms referenced the phrase "honest and impartial" (*gongping zhengzhi*), capturing the idea of standards as touchstones of fairness which Reverend Martin had articulated decades before.

These scientists and engineers enthusiastically promoted their novel system of measurement when the Nanjing government turned its attention to the issue of weights and measures in 1928. By June 1928, the government had charged a handful of trusted men to tackle the issue. The five-member committee included Cai Yuanpei, until recently the head of Peking University (Beida), and Kong Xiangxi, a chief architect of economic and financial policy in Republican China. The other three were Xue Dubi, Niu Yongjian, and Wang Shijie.[129] In reality, some of these men delegated the knotty problem of deciding China's metrological future to their subordinates, including key officials from the new Ministry of Industry and Commerce (*gongshang bu*). At the first meeting of the committee on 21 June 1928, Kong was represented by Xu Shanxiang, his subordinate in the Ministry of Industry and Commerce; Cai delegated his duties to Zhu Kezhen, a geologist and meteorologist who was a faculty member of Beida; and, Xue Dubi sent Cao Shoulin in his stead. Niu attended the meeting in person and Wang chaired

[129] Chengluo Wu, "Zhonghua minguo quandu biaozhun yiersanzhi zhi yanjiu" [An analysis of the 1.2.3. system of weights and measures of the Republic of China], *Gongcheng: Zhongguo gongcheng xuehui huikan* 4, no. 1 (1928): 6.

it.[130] It is worth paying close attention to the minutes of this meeting because the conversation between these five men captures the central tensions which played out repeatedly in the rest of the paper record of the Nanjing government's metrological policy. The few pages, handwritten by Xu Shanxiang, also summarize the prevailing attitudes towards the state of measurement in China and the main proposals for reform in that period.

A GEOLOGIST AND A BUREAUCRAT WALK INTO A ROOM…

Xu opened the meeting by updating the other four men about the government's progress towards finalizing a plan for metrological reform. Officials of the Ministry of Industry and Commerce had already studied the problem of non-standardized weights and measures, and submitted a recommendation to the national government. This report asked the government to endorse one of three options. The first plan asked the government to promulgate the metric system as China's official and only metrological system. The second plan suggested that in addition to going metric, the government should announce a temporary, transitory (*guodu*) set of units which would mediate between metric units and ones which Chinese society were more familiar with. The Ministry suggested a 1.2.3 system, with the market *chi* (*shi chi*) which was a third of the meter (*gonging*); the market *jin* (*shi jin*) which was half a kilogram (*gongjin*), and the market *sheng* (*shi sheng*) being equal to a liter (*gongsheng*). The third option offered a transitory scheme which differed from the 1.2.3 scheme in only one way. Its market chi was equal to a quarter instead of a third of a meter.[131] Xu emphasized that although the second and third options asked the government to allow the use of two sets of units of measurement, in reality, both of these arrangements moved China towards using only the metric system. The sole purpose of

[130] "Tongyi quandu shenchahui jilu (diyici)" [Committee meeting to standardized weights and measures (first meeting)], file 393/2995, SHAC.
[131] "Gongshangbu tiyi qing huayi quandu biaozhun an" [Ministry of Industry and Commerce proposal to standardize metrological standards], file 393/2995, SHAC.

either ancillary system was to ease China into the metric system. Xu summed up by saying that the committee had to make three decisions, namely whether to adopt the metric system as China's official system of measurement; whether there should be a transitory system; and, finally, which transitory system was best.[132]

Xu's record contains only his own remarks on the question of whether China should adopt the metric system as its official system of measurement. He reasoned that if the government decided not to enforce the metric system, it would be necessary to establish a new system of measurement. (By this point, the old Qing *yingzao zhi* had ceased to be a viable option.) He noted that in fact, there were three such proposals, one based on the speed of light (from Ruan Zhiming, a member of the Science Society of China), one based on the length of the equator, and the one jointly devised by Vittrant and Liu. However, unlike the metric system, none of these alternatives had been examined and endorsed by international experts. Without such verification, it was highly improbable that any of them could rival the metric system for global acceptance. The metric system has its flaws, but its international ascendance was undeniable by that point. The meeting's attendees agreed that China should adopt the metric system as its official metrological system, and agreed that there should be a suitable transitory scheme.

The main cleavage which ran through the ensuing discussion was the dilemma between transitory units which were theoretically elegant, and those which were close to popular habit (*minxi*). The committee members split along these lines on two issues. The first was the proposal to define the temporary market *chi* as one third of the *gongchi*, the meter. Cao Shoulin noted that this definition created the problem of a recurring decimal (i.e. $1 \div 3 = 0.333\ldots$), but he supported

[132] "Tongyi quandu shenchahui jilu (diyici)" [Committee meeting to standardized weights and measures (first meeting)], file 393/2995, SHAC.

the proposal since it was so close to the kinds of rulers Chinese people were used to. Zhu Kezhen had more serious misgivings about splitting the meter into three. How do you make a ruler whose length was an endless number? He postulated that allowing manufacturers to produce rulers which were 33.34 centimeters long would solve this problem but introduce another: rulers would all be a *little* longer than the theoretical definition of the unit. This error would be quite small if you measured a short length, but if such a ruler were used to measure longer distances, like the dimensions of a field, that error would snowball. This dispute led the men to throw up alternative definitions of the market *chi*. Zhu suggested three tenths of a meter, and Wang suggested four tenths. The issue remained unresolved at the end of the meeting. The committee could only agree to take up the issue again at its next meeting on July 3.

The second sticky issue discussed by the committee was the question of how many *liang* there should be in a market *jin*. Everyone present agreed that it was acceptable for the market *jin* to be half of the *gongjin*, the kilogram. But how many *liang* should there be in a market *jin*? Wang Shijie asked the men present to address this question. In many parts of China, the *jin* comprised of a certain number of *liang*. This number ranged from twelve to twenty-two, and it was commonly sixteen. But metric purists, and even those who wanted to overthrow the metric, revered its decimal order. To many of the men thinking about bringing order to measurement in China, the clear choice was ten—there should be ten *liang* in a market *jin*. Wang pointed out that if the government defined the market *jin* as 500 grams and divided the market *jin* into ten *liang*, then each *liang* would be equal to 50 grams. This would create the counterintuitive situation where the new market *jin* was lighter than the older definitions of the *jin*, but the new *liang* would be heavier than older definitions of the *liang*. Putting sixteen *liang* in the market *jin* would avoid this problem. This definition would also have the dual advantages of allowing people to

retain a familiar order, and making the policy more easily enforceable. The dilemma between having the market *jin* comprise either ten or sixteen *liang* put these men on the spot. Most of the men who cared about and were involved in designing the policy on weights and measures believed they had the opportunity to rewire some of the bad metrological habits in Chinese society. But this was much more difficult than accommodating some of these habits, especially one as deeply-seated as how many *liang*s are in a *jin*. Cao Shoujin made the link between this question and the preceding discussion about the length of the market *chi*: "Although setting the [*shi*] *chi* as one third of a meter is problematic in theory (*xueli*), in reality it makes the policy easier to enforce. If we switch from sixteen *liang* to ten *liang*, it is theoretically perfect for advancing towards a decimal order, but it will be extremely difficult to enforce."[133]

The people involved with metrological reform in China actually had two problems. The first was deciding what kind of system of measurement China had to adopt, and the second was working out how to ensure that people in China could be induced to use that new system. On the first issue, reformers were unanimous that they wanted a new national system of measurement that had a simple, clear order. When they addressed the second problem, they wanted a transitory metrological system which would feel familiar to most people in China. It was a challenge to resolve both of these problems in a single system of measurement. In the meeting examined above, the trade-off between these two commitments were particularly clear and the attendees acknowledged it openly. In other contexts though, participants in the process of setting China's units of measurements tended to insist that their proposals reconciled *both* of these problems. This is what Liu Jinyu claimed about the system of measurement he and his colleagues had developed. They claimed that the *Yuanren zhi* served both the needs of physicists like Vittrant

[133] Ibid.

and Hu Gangfu, and also the people shopping at Chinese markets. Their counterparts in the Ministry of Industry and Commerce, led by Wu Chengluo and Xu Shanxiang, said the same. They insisted that the 1.2.3 supplementary scheme was the best game plan for metrication in China—it imposed a single set of units which were both close to more familiar units of measurement and yet had a simple relationship with metric units. Wu and Xu argued that these aspects of the transitory scheme meant that it would subconsciously or imperceptibly (*wuxingzhong*) induct China into the metric system.[134] The 1.2.3 transitory system meant that the Nanjing government was pursuing metric order using a mechanism which "accorded with popular habits and mentality."[135]

Under this chorus, these factions had different priorities when they approached the problem of redesigning China's system of measurement. For the majority faction clustered in the Ministry of Industry and Commerce, it was most important that the Nanjing government promulgate a system which was most convenient for China's inclusion in a variety of international activities, most critically trade. From this perspective, the sheer number of countries which had adopted the metric system or allowed its parallel use was conclusive—China must follow the international metric tide.[136] This argument was central in defenses of the government's official policy in the 1920s and the 1930s.

Those who wanted China to resist the metric system felt that it was more important for China to have the right kind of system of measurement, not just the one which was most popular. They also parted ways with those on the pro-metric faction because they saw the metrological

[134] When you think about it, this was a very delicate point that the GMD government was making. The *shichi*—the single ruler they were now asking everyone to use—was both old and new. With this ruler, the GMD wanted to have their cake and eat it too.
[135] Wu, "Zhonghua minguo quandu biaozhun yiersanzhi zhi yanjiu" [An analysis of the 1.2.3. system of weights and measures of the Republic of China], 19.
[136] Wu Chengluo pointed out a similar line of thinking had led to political authorities to embrace the solar calendar, not a new Chinese calendar, years earlier.

needs of scientists and scholars as equal to those of other groups. In one article, Liu argued that if metric units could not serve a physicist in a laboratory, then the metric system could not possibly be appropriate for China. Officials like Wu saw things differently. As the debate over measurement played out across periodicals and newspapers in 1928, Wu became increasingly frustrated with the objections that scientists and engineers had against the metric system. Yes, there was a difference between 33.33… centimeters and 33.34 centimeters. However, this difference was negligible for the kinds of measurement that most people conducted in their everyday lives. He explained that people doing the most common kinds of measurement "do not care about *absolute* scientific accuracy and precision."[137] Most of them would not be concerned with decimal fractions at all. For them the recurring decimal of dividing one by three did not count as a defect in the definition of the market *chi*.[138] From Wu's point of view, scientists were a very small minority. Their niche metrological needs should not define China's system of measurement.

CONCLUSION: A MEASURE OF PROBLEMS

I set out to track the genesis of the problem which the Nanjing government claimed to be putting to rest in 1928. The title of this section alludes not to the multitude of inconveniences which stemmed from the shifting meanings of words like *chi* and *jin* across China, but to the different ways in which people framed the state of measurement in China as problematic. Different people saw different problems with how people in China measured. In the late nineteenth century, the foreigners who began to write about measurement in China insisted that metrological order must be singular. This belief was not an implicit assumption yet. Arthur

[137] Chengluo Wu, "Zhongguo duliangheng zhidu biaozhun zhi yanjiu" [A study of the standards of China's weights and measures], *Gongcheng: Zhongguo gongcheng xuehui huikan* 3, no. 4 (1928): 354.
[138] Wu, "Zhonghua minguo quandu biaozhun yiersanzhi zhi yanjiu" [An analysis of the 1.2.3. system of weights and measures of the Republic of China], 20.

Smith, and even Martin who was more meticulous and less dramatic in his portrayal of measurement in China, openly acknowledged that western countries had only recently moved from the co-existence of many systems of measurement to imposing a single system within each jurisdiction. Their conviction that this was progress led them to see the state of measurement in China as chaos. This view also resonated with their broader appraisals of Chinese society. Messy measurement fit perfectly within the missionary discourse of Chinese inadequacy compared to the west.[139]

The people who did not share the assumption that there should only be one metrological order within China did not see the situation as chaos. These were the shopkeepers who were "seldom ashamed to confess" that they switched between different scales for buying and selling, and who matter-of-factly accepted "two kinds of weights and two kinds of measures" as "*natural* and *normal*, and by no means open to objection."[140] When such people were interviewed by surveyors dispatched by the Nanjing government, they explained the existing arrangements for ensuring accurate measures. The surveyors deployed to Hangzhou found that the city's fifty-nine sectors had various metrological systems and standards. Weights and measures were generally enforced by trade guilds. Members of these associations described practices where members were required to bring their measuring instruments to the association for verification (*zhunjiao*). Sellers of oil used a stone, preserved for generations by their trade guild, as a standard for calibrating their scales. The sellers of timber used a *liangyuan chi* (lit. ruler for measuring round things, circumference) for measuring the circumference of logs.[141] The guild guaranteed the

[139] Liu, *Translingual Practice*, 53-60.
[140] Martin, "The Metric System for China," 57; Smith, *Chinese Characteristics*, 78.
[141] See chapter three, Standardization and Other Histories of Measurement. I deal more expansively with the metrological practices of sellers of oil and logs, including how these practices were changed or not by officials working to enforce the national system of measurement in the 1930s.

length of the *liangyuan chi* by limiting its production to a sole factory in Suzhou (Jiangsu province). The *liangyuan chi* was also a trade secret, revealed only to apprentices—this excluded the surveyors acting on behalf of Nanjing.[142] In sectors where traders were more open, the surveyors were surprised by the high degree of success which associations had in enforcing uniform units of measurement. These included the associations of rice merchants and purveyors of Chinese herbal medicine. Representatives of the latter association emphasized to the surveyors that precise, standardized measures were essential because their line of work affected the preservation of human life.[143] Upon examination, the surveyors found that different purveyors of herbal medicine in Hangzhou used scales which were "absolutely identical" (*haowu chayi*; lit. without any discrepancy).

People in Hangzhou also had arrangements for working with different systems of measurement, not just for enforcing a single one. Two particular associations representing different groups within the silk sector had such an arrangement. One of these groups produced a good which was the raw material for the other. But these two groups used slightly different units for denoting length. To facilitate transactions between these two groups, these associations jointly formed a committee dedicated to measurement. The ten workers elected to this committee had the sole responsibility of flitting between these two systems of measurement. They were a committee of a computer. Representatives of these associations reflected to the surveyors that this system of conversion by committee was working well. The members of these metrological communities experienced these practices as effective tools, and nimbly code-switched between

[142] This would have been very frustrating for the surveyors. Part of their instructions had been to work out the conversion rate between old and new measures in order to adjust prices accordingly, avoiding any confusion in the initial period of enforcement.

[143] See chapter three, Standardization and Other Histories of Measurement: Physicians and pharmacists of Chinese medicine would repeat this concern when they explained why they could not abruptly change the definitions of units of measurement they used when prescribing ingredients for herbal remedies in the 1930s.

the systems which touched their lives. In fact, foreign systems of measurement, most obviously British units of measurement but also the metric, had already wormed their way into Hangzhou by 1931. They had a comfortable, parallel existence with other systems of measurement. Employees in workshops bought imported timber using British units of measurement and used the Chinese *luban* ruler (*luban chi*) for locally sourced materials. The tailors of western clothing used both British and French units of measurement but switched to the local *sanyuan* ruler (*sanyuan chi*) for buying local textiles.[144] People used to metrological multiplicity could incorporate one more variant into their repertoires, even such a strange one as the meter. They did not see their practices as comical, messy, or problematic. There are other histories of measurement here, but they were folded into and overwhelmed by the image of metrological chaos which was broadcast by the kinds of people who wrote essays (and history books), conducted surveys, and shaped official policy.

What existed was a diffuse profusion of authorities which, within their own limited scope, had the power to define different units of measurement. China accommodated different systems of measurement. China's metrological landscape was ordered, but it was ordered *multiply*. This was perceived as cumbersome and chaotic, first by foreigners and then by modernist reformers. To them, varying standards were a problem which cried out for a solution.

This problem was first articulated by foreigners in China in the late nineteenth century, but we should not assume that the Nanjing government addressed that selfsame problem. It is undeniable that scholars and reformers of late Qing and Republican China were intensely aware of and responded to foreign perspectives of China. Tong Lam has found a direct link between

[144] Zhejiangsheng duliangheng jiandingsuo [Zhejiang Province Inspection Center for Weights and Measures], "Hangzhoushi shangyong duliangheng jiuqi zhi baogao" [Report on Commercial Weights and Measures in Hangzhou City], *Zhejiangsheng jianshe yuekan* 5, no. 3 (1931): 1-10.

foreign denigration of China and the conscientious efforts by Chinese social scientists to establish a "culture of fact" surrounding the question of China's total population.[145] *Modern* Chinese medicine was born between the insistence on preserving a national medicine (*guoyi*) and the unrelenting demand it live up to laboratory testing.[146] Grace Shen's study of the birth of modern geology in China pinpoints the 1906 publication of *Record of Chinese Material Resources* by Gu Lang and Zhou Shuren (before he was Lu Xun) as a critical watershed. By presenting what foreigners had managed to learn about China, this work jolted Chinese intellectuals from the comfortable assumption that China's natives knew their own land best. The impetus to know the motherland animated the establishment of geology as a field of expertise and patriotic profession in Republican China.[147] In the 1930s, Chinese social scientists turned towards empirical research especially of China's rural society and economy with the aim of supporting rural reconstruction as a result of the changing priorities of the Rockefeller Foundation, a major source of funding.[148]

The connections are murkier with measurement. Lu Xun read a Japanese translation of Arthur Smith's *Chinese Characteristics* years before he introduced the character of Ah Q in December 1921.[149] It does not take any stretch of the imagination to see how Smith's unflattering portrait of China informed Lu Xun's story. In an early chapter of *The True Story of Ah Q* (*Ah Q zhengzhuan*), Lu Xun's comically vain protagonist claims superiority over the residents of a nearby town based on differences in convention. While people in Ah Q's village, Weizhuang,

[145] Lam, *A Passion for Facts.*
[146] Sean Hsiang-lin Lei, *Neither Donkey Nor Horse: Medicine in the Struggle Over China's Modernity* (Chicago and London: The University of Chicago Press, 2014).
[147] Shen, *Unearthing the Nation.*
[148] Yung-chen Chiang, *Social Engineering and the Social Sciences in China* (Cambridge: Cambridge University Press, 2001), 12, 63-71, 98-99.
[149] Liu, *Translingual Practice*, 52.

called a bench measuring three *chi* and three *cun* wide a "*chang deng* （lit. long bench)," the people in town called this a "*tiao deng* (lit. bench)" instead. And the townspeople used thinner shreds of scallions when they steamed fish compared to the thicker garnish common in Weizhuang. "This is wrong, how laughable!" Ah Q thought.[150] Two years before, in 1919, Hu Shi— another recipient of a Boxer fellowship who switched from studying agriculture to philosophy— had introduced the character of Mr. More-or-less (*Chabuduo xiansheng*). Hu Shi's brief, biting essay satirized lackadaisical indifference to precision in China. Mr. More-or-less bought the wrong kind of sugar, mislabeled Shanxi province (*shanxi sheng*) as Shaanxi (*shanxi sheng*), and ultimately died thinking that being treated by a veterinarian was "almost" like being treated by a physician. But this was not the tragedy Hu Shi wanted to highlight. The tragedy was that the spirit of the character lived on since he was seen as an exemplar by so many in China.[151] In these works, it is possible to see how some Chinese thinkers digested foreign critiques of non-standardization and imprecision in fiction.[152]

The line is less clear in policy. Chinese writing about measurement does not foreground foreign frustration or criticism about measurement in China. Some articles, including those from men involved in shaping the GMD policy, include comments that foreigners were frustrated by the state of measurement in China and that there was some foreign support for standardization. But only Sun Wenyu's update about an ongoing study of weights and measures in China which appeared in an issue of *Kexue* in 1926 addressed foreign writing directly. Sun, a student of

[150] Lu Xun, *Ah Q zhenzhuan shangxi* [Assessments of The True Story of Ah Q] (Taipei: Xinchaoshe wenhua shiye youxian gongsi, 2018), 13.
[151] Hu Shi, "Chabuduo xiansheng zhuan xuanlu" [Selected records of Chabuduo xiansheng], *Xinghua*, 21, no. 26 (1924): 24-5.
[152] What Lu Xun says about varying conventions with Ah Q is ambiguous. It is not clear if the reader is meant to laugh with Ah Q or at Ah Q's scorn for something like this. In one interview discussing China's national character in his work, Lu Xun remarked that the problem of the face-saving Chinaman was a problem only for those who took foreign writing about this character seriously.

agricultural studies, noted that non-standardization had negative effects on China's economy and morality (*daode*). Most importantly, the slippery nature of units of measurement made the task of collecting statistics about any sector or piecing together a snapshot of the national economy, though not impossible, extremely finicky. The survey Sun was involved with was essentially a repeat of the sort of survey which the RAS had tried to conduct in 1889-90. The surveyors asked respondents to indicate the units of lengths, weight and volume extant in different parts of China by indicating these on paper, using stones or wooden blocks, and using standardized containers. In the course of presenting his findings, Sun highlighted that foreigners, including those who had investigated weights and measures in China, made a critical error in mistranslating *shi*, a unit of capacity, as *dan* or the picul, a unit of weight. He noted that the Treaty of Tianjin for example provided rates of conversion for the British pound and the picul. Sun explained that Chinese people typically traded in goods like grain using *shi*, unit of capacity. (They would buy or sell a cup of rice rather than a certain weight of rice.) When foreigners recorded the amounts of grain measured out by the Chinese using units of weight, they inevitably destroyed the order within Chinese practices of measuring these materials using units of volume. Sun cited the second edition of H.B. Morse's *Trade and Administration* (which appeared in 1913) and an excerpt of the work which was published in *Millard's Review of the Far East* in 1917 as a prominent example of this mistake.[153] But beyond this quibble, Sun and his colleagues approached weights and measures with the same kind of assumption that Morse did, namely that China must advance towards a single system of measurement.

It is only possible to say that almost every piece of Chinese writing about the state of measurement in China reflected an intense awareness of the emerging international norm of "one

[153] Wenyu Sun, "Zhongguo dulianghengzhi zhi yanjiu" [A study of weights and measures in China], *Kexue* 11, no. 7 (1926): 876-79.

country, one measure." It became a sort of convention for people writing about weights and measures to provide an overview of the situation in a select group of other countries, most typically France, Britain, the United States, Japan, and Russia. Sometimes, Germany was included. (These countries were all part of the Eight-Nation alliance which intervened during the Boxer Uprising, and had imperialist presences in China.) Some of these surveys were meticulous, detailing precisely how each of these governments made sure that people only used legally-sanctioned units of measurement. They described particulars like how different countries trained personnel to inspect and check measuring equipment, how regularly people were required to license or re-license their equipment, and the types of penalties meted out for using unlicensed instruments. By the 1920s, anybody writing about measurement in China held standardization as the only acceptable endgame. "Unification" (*tongyi*) and "single" (*danyi*) recur in articles, records of meetings, and public education materials.

There was also broad agreement about the kind of system of measurement which China should embrace. In essence, everyone agreed that China's official system of measurement must possess a simple, obvious order. The people who wrote about measurement said this in many ways, but across the board, there was an abhorrence of complication (*fuza*) and a reverence for simplicity (*jiandan*). The metric system gained so many fans in China because of its decimal order—everything was scaled up or down by a factor of ten. The metric's critics wanted a system which would be even more orderly, which would embrace a decimal order even more completely than the metric system.

But beyond this, there were serious disagreements about which system of measurement the government should enforce and how standardization should take place. Everyone wanted a system of measurement which would work for everyone—but when such a candidate could not

be found, some sets of interests were clearly less important than others. When faced with a menu of options, leading voices within the GMD government prioritized having a system of measurement which was understood and accepted internationally over having one which scientists and engineers insisted was theoretically more sound than the metric. The scientists' comments about the proposed transitory scheme were similarly irrelevant for people who preferred designing an enforceable policy. The Nanjing government wanted to order measurement in China, but its devotion to order was not as absolute as that of the engineers or scientists who urged other non-metric ways forward.

CHAPTER 2 NANJING'S REGIME

INTRODUCTION: THE MEANING OF STANDARDIZATION

Public education materials publicizing the Nanjing government's metrological reform all advertised that the government wanted to "standardize weights and measures" (*huayi duliangheng*). This simply meant that it sought to ensure that everyone in China used the same set of weights and measures. One *gongjin* (kilogram) should refer to exactly the same weight, regardless of what was being weighed and where it was being weighed. More infrequently though, reformers would say that they were "unifying" (*tongyi*) China under a single metrological system. *Tongyi* was also the phrase used to describe other projects of national unification, including the GMD's Northern Expedition (1926-28), a military campaign to bring large parts of China under the party's control. Although *tongyi* was less used, and certainly less emphasized in existing studies of the reform, this objective was just as central to the GMD's metrological reform as standardization. By looking closely at the decisions made by Nanjing's officials in the yawning gap between planning and doing, I argue that metrological reform was fundamentally shaped by the pursuit of both standardization and unification. Officials wanted to standardize units of measurement by building a highly centralized system in which only the national government and its agents could make authoritative declarations about accurate measurement in China.

The existence of these intertwined objectives became much clearer between 1928 and 1930 when the slow wheels of the Nanjing bureaucracy creaked towards implementing a new system of measurement. In the middle of 1928, when Chiang Kaishek's (Jiang Jieshi) armies were still trying to fold parts of northeast China into Nanjing's control, a group of bureaucrats began working in earnest to foist another kind of unity across China. In about two and a half

years, they coordinated a frenzy of activity to ensure that a new system of measurement became a reality. In this period, the Nanjing government promulgated two statutes which outlined China's official system of measurement; it also convened two meetings of officials and merchants, one in September 1929, and another in November 1930, to hammer out the details of metrological reform. In September 1928, only a few months after Beijing became Beiping, the Ministry of Industry and Commerce assumed control of a factory in the city where officials kickstarted the process of manufacturing thousands of sets of standards (*biaozhun qi*) and models (*biaoben qi*). In early 1930, the Ministry also issued a call for the first intake of trainees for a three-month program at a training center dedicated to producing inspectors of weights and measures. In the meantime, some provincial and municipal authorities established inspection centers (*jianding suo*), local agencies charged with spearheading the reform in their respective administrative districts. All these developments paved the way for the phased introduction of a new system of measurement across China between 1931 and 1933.

In this flurry of activity, the people involved with metrological reform began to grapple with a different set of questions compared to those which had dominated the earlier discussion about an ideal system of measurement for China. With the course set for metrication, concern now turned to how the government could ensure that the country progressed towards that goal. From the earliest days of this reform, those involved understood that the system would live or die with instruments of measurement. The government had to ensure that people used the right kind of rulers, dippers, steelyards, and weights—namely, those which reflected the new system of measurement. This could only happen if such instruments were, somehow, verified as conforming to the legal system of measurement. Accordingly, in this period, official activity fixated on these two main ingredients for metrological standardization: material standards and

instruments of measurement, and inspectors (*jianding yuan*) who were capable of performing the technical work of assaying instruments of measurement.

In this chapter, I look closely at what reformers said and did as they led a concerted push towards realizing a new system of measurement. As local authorities rolled out the system in 1928-30, officials also raised and addressed initial problems. By reading the record of these discussions and decisions, I clarify what the government wanted to achieve beyond its insistence that it sought "standardization." The speeches and decisions made by the reform's most prominent leaders emphasized that the campaign would teach Chinese society accuracy (*biaozhun*) and that it was a foundational step, even *the* foundational step, towards national unity. In practice, they designed and set in place a highly centralized system to manage the error (*chashu*) of instruments of measurement and guide the crucial process of assaying (*jianding*) instruments of measurement. Overall, the practices finalized in Nanjing amounted to a comprehensive regime of authentication to govern measurement in China. In this highly centralized and intensely supervised system, the authority of every instrument of measurement would be conferred only by one center. Nanjing was to be the ultimate and sole center of China's metrological universe—a reflection and consequence of its status as the capital of a unified China, however remote that ideal might be. Reformers in Nanjing insisted on a high degree of centralized control even when there were pressing constraints which militated against this objective. Even if it would take immense expense and trouble, the Nanjing government had to have the *exclusive* right to call a meter (and so on, and so forth) that, and to impose its chosen system of measurement across the country.

FOUNDING A METROLOGICAL REGIME

The national political stage was chaotic in the republican interregnum (1911-1949). The organizations claiming national leadership were fractured, weak, or even non-existent. The Qing's republican successor in Beijing was soon overtaken by Yuan Shikai's political ambitions. Yuan, a military leader who had risen to national prominence under the Qing, managed to force Sun Yatsen (Sun Zhongshan) to cede control of the national government, but soon faced a Second Revolution against his government in 1913. Even though the Beijing government survived this revolt, it was disturbed again by Yuan's announcement that he intended to resurrect the barely dead imperial institution in late 1915. After the failure of this attempt and Yuan's death in June 1916, political control in China devolved to regional figures, each enforcing control of their regional fiefdoms using armed forces. Although the GMD's Northern Expedition technically ended the period of warlordism, Nanjing did not have full or stable control of the country. The Nanjing decade (1927-37) was punctuated with multiple provincial rebellions. Warlords also retained control over parts of the country, especially the northeast. Additionally, the persistent existence of the Chinese Communist Party (CCP) continued to pose a threat to Nationalist rule.

Against this backdrop, it is, perhaps, unsurprising that existing scholarship highlights that the dynamic centers of significant changes lay beyond the national political mayhem. Regional leaders like the Guangdong technocrat Feng Rui picked up some of the political slack by planning and working to build a national economy which integrated agriculture and industry.[154] Other groups like the Joint Terminology Commission, a regional, private undertaking, undertook the finicky but essential task of standardizing Chinese-language terms for parts of the human

[154] Emily M. Hill, *Smokeless Sugar: The Death of a Provincial Bureaucrat and the Construction of China's National Economy* (Vancouver and Toronto: UBC Press, 2010).

anatomy.[155] Grace Shen has recently shown that, counter-intuitively, geologists could not rely on the state as a reliable partner for developing the field during the relatively stable period of the Nanjing decade. In the face of institutional stability and patchy financial support, geologists were only able to succeed in advancing their research and teaching goals, and the geological survey of China because of their own ingenuity, resourcefulness, and self-sacrifice.[156] A recent edited volume, *Knowledge Acts in Modern China*, likewise downgrades the centrality of the state in the formative periods of many academic and professional disciplines in Republican China. In fields like railroad engineering for example, official directives or policies had almost no part to play in establishing the sector; instead, it was market demand for this kind of expertise which was decisive.[157] There is a consensus Republican China witnessed many significant developments, but many of these occurred beyond or even despite the central government.

But the state was hardly marginal in at least one important way. The national government endured as the final arbiter of legitimate practice or knowledge claims— and this role was consequential. In Sean Lei's telling, the emergence of modern Chinese medicine, a tradition which differed from both western biomedicine and older Chinese practices, was a case in point. A crucial factor in this process was the interplay between the government's insistence that herbal remedies in Chinese medicine fulfill certain requirements of laboratory testing, and the conviction on the part of the champions of national medicine that obtaining official accreditation was imperative, or at least valuable.[158] In the case of metrological reform, we see more than just the exercise of this legitimating authority, or how other groups responded to it. The decisions and

[155] Luesink, "Dissecting Modernity."
[156] Shen, *Unearthing the Nation*, 109-43.
[157] Elisabeth Köll, "The Making of the Civil Engineer in China: Knowledge Transfer, Institution Building, and the Rise of a Profession," in *Knowledge Acts in Modern China*, eds. Robert Culp, Eddy U, and Wen-hsin Yeh (Berkeley: Institute of East Asian Studies, 2016), 148- 173.
[158] Lei, *Neither Donkey nor Horse*.

discussions which took place in this early phase of the reform take us behind the scenes to *the making of this authority*. What did it mean for the Nanjing government to serve as the ultimate authority on accurate measurement in China? In what ways would the national government in Nanjing be connected to the millions of rulers and weights which ordinary people would use all around the country? Between 1928 and 1930, those involved in metrological reform answered these questions by crafting the basic elements necessary for making the new metrological system real. These comprised the statutes which gave the system of measurement legal standing; a supply of material standards and instruments of measurement which could meet the needs of the whole country; enough inspectors who possessed the technical know-how to ensure that the new system of measurement was being reproduced and used; and, a plan to progressively roll out the new system of measurement throughout the country. The overall system established by officials upheld and defended Nanjing's authority on everything metrological.

In 1928 and 1929, the Nanjing government confirmed its metrological goals in statutes and finalized plans to enforce its chosen system of weights and measures across the country. In July 1928, the government promulgated the Metrological System of the Republic of China (*Zhonghuaminguo quandu biaozhun fangan*).[159] This two-clause statute announced that China was adopting the metric system (*wanguo gongzhi*) as its standard system of measurement, (*biaozhun zhi*). The basic unit for length, the standard *chi* (*biaozhun chi*) was the meter (*gongchi*, or *mitu chi*); the basic unit for volume, the standard *sheng* (*biaozhun sheng*) would be the liter (*gongsheng*, or *lite*, equal to 1,000 cubic centimeters); and the basic unit for weight, the standard *jin* (*biaozhun jin*) would be equal to one kilogram (*gongjin*; 1,000 grams). The second clause

[159] Shiye bu quanguo duliangheng ju [Ministry of Industries, National Bureau of Weights and Measures], *Zhongyang ji geshengshi duliangheng fagui huikan* [Compilation of Central, Provincial and Municipal Regulations Regarding Weights and Measures] (Nanjing: Shiye bu quanguo duliangheng ju, 1933), 1.

introduced the auxiliary market system (*shiyong zhi*) and noted specifically that it had the dual benefits of being easily converted to the standard system while resembling units of measurement which were familiar or already popular in China. In this secondary system, the basic unit for length was the market *chi* (*shi chi*), defined as a third of the meter; the basic unit for weight was the market *jin* (*shi jin* 市斤), which was equal to half a kilogram; and the basic unit for volume, the market *sheng* (*shi sheng*) was defined as equal to the liter. The market system also deviated from the standard system's strict adherence to a decimal logic. The July 1928 law laid out two of these deviations. First, the important unit for measuring land, most critically in property deeds, the *mu* was equivalent to six thousand square market *chi*. Second, the market *jin* was not divided into ten but sixteen *liang* of 31.25 grams each.[160] These numbers— 6,000, 16, 31.35— ruptured the neat rows of ones and zeros which populate tables explaining the metric system.

Table 1: Units of Measurement in the Metrological System of the Republic of China (*Zhonghuaminguo quandu biaozhun fangan*), 1928

	Standard system (*biaozhun zhi*) = Metric system (*wanguo gongzhi*) (clause 1)	**Market system (*shiyong zhi*) (clause 2)**
Length	Standard *chi* (*biaozhun chi*) = 1 meter (*gongchi, mitu chi*)	Market *chi* (*shiyong chi*) = 1/3 standard *chi*
Area	No units defined	1 *mu* = 6,000 square market *chi*
Volume	Standard *sheng* (*biaozhun sheng*) = 1 liter (*gongsheng, lite*)	Market *sheng* (*shiyong sheng*) = standard *sheng*
Weight	Standard *jin* (*biaozhun jin*) = 1 kilogram (*gongjin*)	Market *jin* (*shiyong jin*) = ½ standard *jin* 1 market *jin* = 16 *liang* (31.25 grams)

Source: Metrological System of the Republic of China (*Zhonghuaminguo quandu biaozhun fangan*), promulgated July 1928.

The Nanjing government's first metrological law only named and defined eight units of measurement. This list was by no means a full system of measurement which could service the needs of everyone in China. (There was no guidance, for example, on the units which could be

[160] In the first report of the Training Center for Inspectors of Weights and Measures, in a speech delivered to trainees or graduates, Xu Shanxiang pins the retention of 16 *liang* squarely on the needs of Chinese medicine.

used to measure longer lengths like the distances of journeys, or to measure very minute lengths.) More than half a year later, the government finally fleshed out a comprehensive system of measurement in the Law of Weights and Measures (*Duliangheng fa*) in February 1929.[161] This law anchored measurement in China to the metrological system which had been developed, elaborated, and affirmed in France. In addition to confirming that the meter and the kilogram (metric units) were the standard ones in China, the Law pinned the standard *chi* and the standard *jin* to the original (international) standards (*yuanqi*, lit. original instruments), made of a platinum-iridium alloy and preserved in the International Bureau of Weights and Measures (Clause 1).[162] This Law made clear that China was going metric. The second clause confirmed that China only had one system of measurement, the standard system; the market system was an auxiliary system (*fu zhi*) which was meant to ease Chinese society into the metric system.[163]

The next three clauses laid out two families of units of measurement— one set for the standard system, and another for the market system. Clause 4 defined and named twenty-seven units in the standard system to measure length, area, volume, and weight.[164] Clause 5 reiterated the definitions of the market *chi*, the market *jin*, and the market *sheng*. It also listed the three exceptions to decimalization in the market system: the *li* was equal to 1,500 *chi*, the *mu* consisted of 6,000 square market *chi*, and the *jin* was equivalent to sixteen *liang*.[165] The sixth clause

[161] Shiye bu quanguo duliangheng ju [Ministry of Industry, National Bureau of Weights and Measures], *Duliangheng fagui huikan* [Compilation of Central, Provincial and Municipal Regulations Regarding Weights and Measures], 4-8.
[162] Ibid., 4.
[163] Ibid., 4. The coherence and unity of these two systems, already a concern to those who deliberated the design of this scheme, would continue to trouble administrators in subsequent years.
[164] Ibid., 4-6.
[165] Ibid., 6.

defined and named twenty-seven units of measurement in the market system to measure the same four dimensions.[166] [167]

These two statutes— the Metrological System of the Republic of China (1928) and the Law of Weights and Measures (1929)— constituted the basic legal basis for metrological reform. Having established this statutory foundation, the Nanjing government moved to put the meter, the liter, and the kilogram first, into the hands of its provincial and municipal agents, and then into those of ordinary people. In September 1928, the Ministry of Industry and Commerce dispatched Chen Jingyong to take control of the Weights and Measures Factory (*Quandu zhizaosuo*) in the city. In his report on the operations of the Beiping factory to his superiors in Nanjing the next year, Chen recalled the factory was in a bad state at the time. When the factory began operations on 1 October 1928, the production of standards took place concurrently with repairs to the factory's damaged facilities and machines. Production was also hampered by the difficulty of employing skilled workers. Since the government had yet to finalize the specifications for new standards, the few workers in the factory could only modify old instruments to suit the new units. In this initial phase, the workers seemed to have worked exclusively on producing rulers, the simplest kind of instruments.[168]

Production at the government's sole factory of this kind only gathered steam in early 1929. After the promulgation of the Law of Weights and Measures in February, Chen was

[166] Ibid., 6-7.
[167] The standard system and market system did not exactly mirror each other in that they each contained 3 units of measurement which had no counterpart in the other system. The market system included 3 units which had no counterpart in the standard system: *hao* 毫, the smallest unit for measuring length (defined as 0.0001 of the market *chi*; 0.003333 m); another *hao* 毫, the smallest unit for measuring area (defined as 0.0001 of the market *mu*); and, *fen* 分, defined as 0.1 of the market *mu*. The standard system had 3 units of measurement which had no counterpart in the market system: *gongheng* 公衡, equal to 10 kilograms; *gongheng* 公衡 (10 kilograms), and *gongdun* 公噸 (1,000 kilograms). See Appendix A for full list of units named and defined in the Law of Weights and Measures (1929).
[168] Jingyong Chen, "Zhizao zhi jingguo qingxing ji jianglai banfa" [Overview of manufacturing thus far and future plans], file 613/349, SHAC.

summoned to Nanjing for a meeting in March. His marching orders were to hire enough workers to produce 100 sets of standards (*biaozhun qi*)[169] and 100 sets of models (*biaoben qi*) per month. This was supposed to be sufficient to supply at least one set of standards (*biaozhun qi*) for all national agencies, and provincial, municipal and county governments, as well as the demand for models (*biaoben qi*) to guide the mass manufacture of instruments of measurement in privately-run factories for general use. On 1 April 1929, the Beiping factory set out to meet this goal. Although the factory's operations were temporarily disrupted in late April,[170] the factory continued to churn out standards according to this pace in the following months.[171]

Additionally, workers at the factory also undertook the highly important and delicate task of assaying (*jianding*) their products. Chen reported that the factory's small team of inspectors, one inspector (*jianding yuan*) and three assistants (*jianding sheng*), started this task in October 1928. The factory had retained old steel-nickel weights which had been produced in France. (These might have been the standards which the Qing had charged its representatives in France to obtain in its final years but it is unclear.) These were taken to be China's original standards (*yuanqi*).[172] These *yuanqi* were used to confirm the accuracy of eight sets of weights for the standard system and nine sets of weights for the market system. These seventeen sets of weights were also checked and calibrated, and workers confirmed their sensitivities (*ganliang*). Finally, they were all "finely assayed" (*jingxi jianding*) before they were given the status of vice-original

[169] Each set of standards (*biaozhun qi*) consisted of a ruler for the standard system (1 meter); a ruler for the market system (1/3 meter); a standard liter; a set of weights for the standard system; and, a set of weights for the market system.
[170] The site of the Beiping factory was at the center of a property dispute between the Ministry of Industry and Commerce and a group of students from the First Engineering College, Peking University in late April 1929. This dispute was unrelated to the work of metrological reform.
[171] Jingyong Chen, "Zhizao zhi jingguo qingxing ji jianglai banfa" [Overview of manufacturing thus far and future plans], file 613/349, SHAC.
[172] In September 1930, the Ministry's Implementation Commission would recommend commissioning a new set of *yuanqi* from Geneva.

standards (*fu yuanqi*). Perhaps by way of explaining the extraordinary slowness of progress, Chen emphasized that because these standards would be used to verify the accuracy of other instruments, it was absolutely essential to verify them thoroughly and precisely. The delicacy and time-consuming nature of the work also gave Chen cause to request for additional resources from Nanjing.[173]

The GMD government obliged these requests by sending individuals with relevant experience to Beiping and authorized Chen to call for new trainees at the factory.[174] But more broadly, the Ministry of Industry and Commerce also invested in training a corps of inspectors to enforce the system across the country. Many leaders of metrological reform recognized that their project hinged on having a group of people who would enforce it on the ground. In February 1930, the national government issued a call for the first intake of trainees at the Training Center for Inspectors of Weights and Measures (*Duliangheng jianding renyuan yangchengsuo*) located in Nanjing. To qualify to join the advanced class, prospective students had to have a university degree in science or engineering (or equivalent). Trainees in the elementary class only needed to have graduated from senior high school.[175] In 1930, a total of 118 inspectors traveled to Nanjing and completed the three-month curriculum.[176] The program prioritized introducing students to the regulations they would be enforcing, and also gave students practical experience with key aspects of their job: manufacturing and inspecting instruments of measurement, drafting

[173] Jingyong Chen, "Jianding gongzuo zhi jinguo qingxing ji jianglai banfa" [Overview of inspection thus far and future plans], file 613/349, SHAC.
[174] Ibid.
[175] Gongshang bu [Ministry of Industry and Commerce], "Guizhang" [Regulations] in *Gongshang bu quanguo duliangheng ju duliangheng jianding renyuan yangchengsuo diyici baogaoshu* [First report of the Training Center for Inspectors of Weights and Measures] (Nanjing: Zhonghua yinshua gongsi, 1930), 2-4.
[176] Ibid., "Tongji" [Statistics], 21.

conversion rates between units of measurement, drafting (drawing), and public education.[177] In the following years, provincial and municipal governments continued to send trainees to the capital.

The Ministry of Industry and Commerce also spearheaded the process drafting a schedule to introduce the new system of measurement throughout China. In April 1929, the Ministry of Industry and Commerce finalized regulations to convene a Metrological Reform Implementation Commission (*Dulianghang tuixing weiyuanhui*) (hereafter, Implementation Commission).[178] This small group of about thirty men met in Nanjing between 24 and 30 September 1929 to hammer out a plan for national implementation. The group was dominated by bureaucrats—several from the Ministry of Industry and Commerce, and a representative from all other ministries.[179] Two other commissions were invited to be represented in this meeting: that overseeing Mongolia and Tibet, and the National Reconstruction Commission (*Jianshe weiyuanhui*). The Ministry also invited the National Federation of Chambers of Commerce (*Quanguo shanghui lianhehui*) to send three representatives.[180]

The commission set the broad outlines of the campaign which the National Bureau of Weights and Measures would execute in the ensuing years. It set the pace for rolling out the campaign across the country. All public agencies and organizations were supposed to switch to

[177] Gongshang bu [Ministry of Industry and Commerce], "Guizhang" in *Gongshang bu quanguo duliangheng ju duliangheng jianding renyuan yangchengsuo diyici baogao shu* [First report of the Training Center for Inspectors of Weights and Measures], 3.
[178] Gongshang bu [Ministry of Industry and Commerce], *Gongshang bu duliangheng tuixing weiyuanhui huiyi huibian* [Compilation of meeting materials of the meeting of the Metrological Reform Implementation Commission of the Ministry of Industry and Commerce], 1-2.
[179] Specified ministries: Ministry of Interior of Affairs; Ministry of Foreign Affairs; Ministry of Finance; Military; Navy; Ministry of Transport; Ministry of Railways; Ministry of Agriculture and Mining; Ministry of Education; Ministry of Health; Ministry of Law. The Ministry also specified that Shanghai municipality should send a representative, but this person failed to make it to the meeting.
[180] Gongshang bu [Ministry of Industry and Commerce], *Gongshang bu duliangheng tuixing weiyuanhui huiyi huibian* [Compilation of meeting materials of the meeting of the Metrological Reform Implementation Commission of the Ministry of Industry and Commerce], 1.

the standard system by the end of 1930. The commission specified that the Ministry of Education should include both the standard and market systems in all educational materials, and that China's diplomats had about fifteen months to inform all foreign countries that the government would deal exclusively in metric units. The commission asked the national government to hold the foreign-run Maritime Customs to the same deadline. China's armed forces and navy, already metric, were directed to use only the nomenclature specified in the 1929 Law of Weights and Measures.[181] The rest of the country was supposed to follow the example of government agencies between 1931 and 1933. In 1931, local officials in seventeen provinces and all special municipalities, mostly located along China's eastern seaboard, were supposed to push the populations within their administrative jurisdictions to adopt the market system. In the next two years, two more groups of provinces were scheduled to achieve this objective too.[182] Although the original proposal submitted for consideration by the Ministry of Industry and Commerce laid out a six-year timeline, coinciding exactly with the duration of political tutelage (*xunzheng*) prescribed by Sun Yatsen, the meeting shortened this, setting the target that everyone would be using either the standard or market system by the end of 1933.[183] This truncated timeline might have seemed reasonable based on the fact that Shanxi province achieved complete metrological standardization within eight months in 1919 according to Chen Jingyong.[184] The final plan gave provinces and municipalities a generous eighteen-month period to achieve the same.

By late 1929, the Ministry of Industry and Commerce had made great strides towards preparing to enforce the new system of measurement. It began issuing directives asking local authorities and agencies to order and pay for standards and models from Beiping, to prepare

[181] Ibid., 21-22, 22-24, 24-25.
[182] Ibid., 19.
[183] Ibid., 47-50.
[184] Ibid., 33.

materials for public education campaigns to explain the reform to their residents, and to move towards establishing their local inspection centers. Local authorities, especially those governing regions included in the first phase of implementation, sprang into action. In October 1929, municipal authorities in Qingdao (Shandong province) convened a meeting with local merchant associations to discuss metrological reform.[185] In November 1929, Hankou's (Hubei province) municipal government informed the ministry that it had received the new standards and was in the process of licensing local manufacturers of instruments of measurement.[186] In early 1930, authorities in both Hankou and Shanghai kickstarted public education campaigns which highlighted the problems with the current state of measurement in China and touted the GMD government's scheme as convenient, scientific, and essential for economic reconstruction (*jingji jianshe*).[187] By April 1930, Shanghai had its own municipal inspection center of weights and measures.[188] Half a year later, there were similar agencies in Nanjing municipality, and Zhejiang and Fujian provinces.[189]

The road to standardization was not smooth. The national bureaucratic network of agencies dedicated to metrological standardization did not grow as quickly as scheduled. According to the national schedule for implementation, provinces and municipalities were supposed to establish their provincial or municipal inspection centers (*sheng jianding suo*, or

[185] "Hui cheng huayi duliangheng jihua qing shidao you" [Announcement of plan to standardize weights and measures for compliance], *Qingdao shehui*, no. 2 (1930)122.
[186] *Hankoushi zhengfu* [Hankou municipal government], "Chengbao tuixing duliangheng qingxing you" [Report on Implementation of Weights and Measures Reform], file 613/317, SHAC.
[187] "Hankoushi huayi duliangheng xuanchuan dagang" [Overview of Public Education for Standardization of Weights and Measures in Hankou Municipality], *Xinhankoushi shizheng gongbao* 2, no. 6 (1930): 79-87; "Duliangheng qianshuo" [Brief discussion on weights and measures], *Shehui yuekan* 2, no. 7 (1930): 1-12.
[188] "Shanghaishi duliangheng jiandingsuo guicheng" [Regulations governing Shanghai municipal inspection center for weights and measures], *Gongshang banyue kan* [Semi-Monthly Economic Journal] 2, no. 20 (1930): 14-15.
[189] Shiye bu [Ministry of Industries], *Gongshangbu quanguo duliangheng huiyi huibian* [Compilation of materials of the National Weights and Measures Meeting of the Ministry of Industry and Commerce] (Nanjing: Zhonghua yinshua gongsi, 1931), 6.

tebieshi jianding suo) eighteen months before their respective deadlines to achieve local metrological standardization.[190] For the seventeen provinces and seven municipalities included in phase one, this deadline was 31 December 1931. This meant that these governments were supposed to have established local inspection centers by June 1930. But by November 1930, only four of these centers had been established (Nanjing, Shanghai, Fujian province, Zhejiang province). Local officials based in different parts of the country complained of a lack of financial resources, and asked the central government to provide both financial support and guidance on how to establish these agencies.[191] Some also highlighted that local governments did not seem to understand or prioritize metrological reform, and requested for national authorities like the Ministry or the Administrative Yuan (*Xingzheng yuan*) to raise the profile of the campaign. However, the Ministry was itself guilty of this administrative foot-dragging. Although it was scheduled to establish a National Bureau of Weights and Measures (*Quanguo duliangheng ju*) on 1 January 1930 (the date on which the Law of Weights and Measures came into effect), this national agency was only born in September 1930, most likely in response to a barrage of official appeals to do so from local governments.[192]

Local governments also faced difficulty recruiting candidates for the Training Center in Nanjing. Calls for trainees did not attract enthusiastic responses. As a result, the national training center was not producing enough inspectors according to the four-year timeline for completing metrological standardization. The Ministry's first call for trainees issued in February 1930 called

[190] This was the end of 1931, the end of 1932, and the end of 1933 respectively for administrative units in each of the three-phase schedule.
[191] Shiye bu [Ministry of Industries], *Gongshangbu quanguo duliangheng huiyi huibian* [Compilation of materials of the National Weights and Measures Meeting of the Ministry of Industry and Commerce], 66-68, 83-85, 107-120.
[192] "Zi caizhengbu gongzi di sanqisiqi hao" [Correspondence with Ministry of Finance No. 3747], *Gongshang gongbao*, no. 37 (1930): 4.

for a total of 183 students— 60 in the elementary class, and 123 in the advanced one.[193] Yet, after *two* intakes in late 1930, only 118 inspectors had graduated from the training center.

Perhaps the most vexing issue was the government's inability to deliver standards and models across China. Although the production of these instruments had proceeded apace in the Beiping factory, there were bottlenecks and bumps in distributing these materials to other parts of China. The Ministry noted that this problem was particularly severe in inland areas, specifically the ten provinces of Rehe, Ningxia, Xinjiang, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, and Xikang. These places could only be accessed or traversed (relatively slowly) using vehicles running on wind power, manpower, or animals. Efforts to deliver standards across the country had also been stopped by armed forces or local officers in charge of collecting taxes and fees who did not understand the nature of these materials, and either prevented their conveyance or attempted to impose fees. Standards were sometimes even damaged or lost in the commotion.[194] Furthermore, although there was an existing procedure of issuing passports attesting to the nature of these instruments, the process was ponderous, requiring the Ministry of Industry and Commerce to apply for these passports from the Ministry of Finance, and then to post these passports to relevant distribution points.[195] All of these obstacles amounted to delays in delivering standards which local authorities had ordered and paid for.

[193] Gongshang bu [Ministry of Industry and Commerce], "Gongdu" [Official documents] in *Gongshang bu quanguo duliangheng ju duliangheng jianding renyuan yangchengsuo diyici baogao shu* [First report of the Training Center for Inspectors of Weights and Measures], 4-5.
[194] Shiye bu [Ministry of Industries], *Gongshangbu quanguo duliangheng huiyi huibian* [Compilation of materials of the National Weights and Measures Meeting of the Ministry of Industry and Commerce], 19-22.
[195] Ibid.

NEW RULERS, OLD ENDS

Despite these difficulties, high-ranking officials within the Ministry of Industry and Commerce pressed on with metrological reform. They explained that the work was important, even urgent, because it was a foundational step towards building a strong, unified China. Even though political disunity was a hallmark of republican China, including the Nanjing decade, there was a remarkably consistent dedication to the idea of one China which roughly stretched across the territory of the Qing and encompassing the population therein. Even though national unity was in tatters, it endured as the ideal end-state. Perhaps no one spoke (or dreamt) more fervently of this than Sun Yatsen. Even while he temporarily retreated from national politics in Shanghai, Sun penned *The International Development of China*, a promotional booklet advertising China as an unbeatable destination for foreign investment. In it, he sketched his vision for building an industrialized, integrated national economy where large, centralized government agencies efficiently plan and execute a variety of essential tasks. These included constructing and furnishing modern apartments for China's large population, complete with modern sewage, running water, and telephones; and, coordinating the production and distribution of essentials like food and clothing. He was appealing to international donors to support huge infrastructural projects, most critically a monumental plan to connect the whole country via railroads, roads, and canals.[196] For Sun, the government had a very active and continuing role to play in both unifying China, and guaranteeing the well-being of Chinese society.

Historians have noted that this text was particularly influential, serving as a kind of spiritual roadmap for GMD ideologues and technocrats even after Sun's death in 1925.[197]

[196] Yatsen Sun, *The International Development of China* (New York and London: The Knickerbocker Press, 1922).
[197] William Kirby, "Engineering China: Birth of the Developmental State, 1928-1937," in *Becoming Chinese: Passages to Modernity and Beyond*, ed. Wen-hsin Yeh (Berkeley: University of California Press, 2000), 137-53;

Metrological reformers of the Nanjing decade also seemed to act in its spirit; many believed that they were pursuing both national unity and the social good. In particular, the reform's most prominent leaders consistently framed metrological reform as a state-building project rooted in age-old political wisdom. When he spoke at the graduation ceremony of the first cohort of inspectors at the training center, the Minister of Industry and Commerce, Kong Xiangxi, waxed lyrical about how the reform would order all things in the broadest sense, and set everything on par.[198] In effect, Kong argued, ordering units of measurement would rebut foreign criticism about the utter lack of established standards in China. Wu Chengluo also imbued metrological standardization with lofty significance when he explained the reform in a radio address on 6 September 1929, about a fortnight before the Implementation Commission was due to meet. Wu devoted most of his speech to expounding the deep relationship between defining units of measurement and statecraft in China. Wu tracked the state's responsibility for standardizing weights and measure to the very beginning of (recorded) history in China. This was a duty acknowledged and carried out since the time of China's Five Legendary Emperors (*wudi*),[199] and the first three dynasties (*sandai*).[200] The idea that good governments had a metrological duty to the governed had deep roots in Chinese political thinking, as recorded in the Five Classics (*wujing*)[201] and Four Books (*sishu*).[202]

Jeremy Tai, "The Northwest Question: Capitalism in the Sands of Nationalist China," *Twentieth-Century China*, 40, no. 3 (October 2015): 201-219.

[198] Gongshang bu [Ministry of Industry and Commerce], *Gongshang bu duliangheng tuixing weiyuanhui huiyi huibian* [Compilation of meeting materials of the meeting of the Metrological Reform Implementation Commission of the Ministry of Industry and Commerce], 30-31.

[199] The Five Legendary Emperors were the Yellow Emperor (Huangdi), Zhuan Xu, Di Ku, Tang Yao (Yao), and Yu Shun (Yu).

[200] The Three Dynasties were the Xia dynasty, the Shang dynasty, and the Zhou dynasty.

[201] The Five Classics are the Book of Songs (*Shijing*), the Book of History (*Shujing*), the Classic of Rites (*Lijing*), the Book of Changes (*Yinjing*), and the Spring and Autumn Annals (*Chunqiu*).

[202] The Four Books are the Book of Great Learning (*Daxue*), the Doctrine of the Mean (*Zhongyong*), the Analects of Confucius (*Lunyu*), and the Book of Mencius (*Mengzi*).

Wu's reading of these classics put standardizing weights and measures at the heart of establishing sound governance in China. In the Analects (*Lunyu*), unifying all of society under one system of measurement was the foremost of the essential tasks of government. The Book of History (specifically the *Yushu*) contained a quote which explained the important goal of this task: "standardizing weights and measures will unify places, near and far, and establish society's trust [in the government]" (*nai tonglu duliangheng suoyi qiyuanjin liminxin ye*). The ultimate end was establishing people's trust (*minxin*) in the government. Confucius had clarified the absolute importance of this element for governance in a dialog in the Analects. Confucius counseled his interlocutor that if governments met people's basic needs by securing their livelihoods and physical safety, they would earn the trust of the people. Confucius' respondent asked which of these three should be abandoned in situations where it was not possible to achieve such an idealized state. In line with his emphasis on moral governance, Confucius replied that armies were the least important. When his interlocutor asked again which of the remaining two— adequate food and the people's trust— could be sacrificed, Confucius underlined that the latter, *minxin*, absolutely could not be compromised.[203] This element— the trust of the people— was the ultimate and most important result of ordering units of measurement. For Wu Chengluo, these quotations from the classics underscored the huge significance of the current metrological reform. Defining and enforcing standardized units of measurement was the first important step in establishing a contract between the ruler and the ruled. The Nanjing government's metrological reform went to the core of the effort to establish a functioning government—the lack of which was keenly felt in Republican China.

[203] Gongshang bu [Ministry of Industry and Commerce], *Gongshang bu duliangheng tuixing weiyuanhui huiyi huibian* [Compilation of meeting materials of the meeting of the Metrological Reform Implementation Commission of the Ministry of Industry and Commerce], 87-95.

China's current state of political disunity weighed heavily on the minds of those involved with metrological reform. They believed that they were building "One China" by applying Nanjing's metrological law across the land. They made this link explicitly when they spoke or wrote about their work. At a meeting previewing metrological reform to about five hundred GMD members in July 1929, Zhao Yifeng told GMD members that the use of a single system of weights and measures across the country would be a sign of national unification.[204] When leaders of the reform spoke to inspectors, they gravitated towards language which drew parallels between inspectors of weights and measures and soldiers who were fighting to unify China. When he spoke to trainees at the training center for inspectors in 1930, Cheng Lin, a bureaucrat who would go on to head both the training center and the Beiping factory, claimed that inspectors were an elite, technical corps which played even more important roles than soldiers in uniting China because metrological unity was more foundational than political unity.[205] At a graduation ceremony, Zhu Wenzhong, a representative from the Nationalist government, likewise called on graduates to approach their jobs with a "fighting spirit" (*fendou jingshen*) because they, like the soldiers of the Northern Expedition, were working to unify China.[206] National unification was also literally front and center of all publications from the national Bureau of Weights and Measures. These official publications invariably carried a map of China on the cover; it was color-coded to indicate the areas included in each of the three-phase

[204] "Tebie dangbu zuo kai tongyi duliangheng xuanchuan dahui" [Special party meeting to kickstart standardization of weights and measures held yesterday], *Zhengjiao shuwen*, no. 547 (1929): 13-14.
[205] Gongshang bu [Ministry of Industry and Commerce], "Yanjiang" [Speeches] in *Gongshang bu quanguo duliangheng ju duliangheng jianding renyuan yangchengsuo diyici baogao shu* [First report of the Training Center for Inspectors of Weights and Measures], 16, 18.
[206] Gongshang bu [Ministry of Industry and Commerce], "Biye dianli" [Graduation ceremony] in *Gongshang bu quanguo duliangheng ju duliangheng jianding renyuan yangchengsuo diyici baogao shu* [First report of the Training Center for Inspectors of Weights and Measures], 5-6.

implementation schedule, and underlined that behind the reform was the grand dream of one China under one measure.

Another recurring idea was that standardizing weights and measures was an important "foundation" (*jichu*) or "basic" (*jiben*) for "economic reconstruction" (*jingji jianshe*). Most of such statements did not further elaborate on how one of these things would pave the way for the other. But in all likelihood, those who insisted on the fundamental nature of standardized weights and measures probably shared the concerns of Shan Gong, an agriculturalist. Writing in a regional periodical in 1928, Shan argued that because so much of China was still agrarian, economic development had to include and even focus on this sector. From his perspective, the biggest roadblock to agricultural development was the sorry state of statistics (*tongji shiye*) in China. Shan highlighted that even the modest project of trying to gauge the amount of grain bought and sold in the city of Nanjing required the use of different units of measurement, reflecting the inconvenient metrological diversity across China. It was clear to him that the first step towards developing agriculture, and in turn, the national economy, was standardizing weights and measures. Although earlier standardization projects had faltered, Shan hoped that the current one might finally set China on the path towards greater agricultural production.[207] Officials from the Ministry of Industry and Commerce had the same general idea when they argued that it was especially important for the Maritime Customs to use only China's new system of measurement. As the office taxing, and hence, overseeing international trade into and out of China, the Customs was a crucial "pivot" for collecting statistics to understand, for

[207] Shan Gong, "Gailiang nongye yu tongyi duliangheng zhidu" [Improving agriculture and standardizing weights and measures], *Xinguangxi xunbao*, no. 17 (1928): 12-16.

instance, global demand for Chinese goods.[208] The Ministry's officials argued that standardizing weights and measures would lay the foundations for the systematic collection of vital statistics to inform economic planning.[209]

In order to reap these impressive benefits, officials had to ensure that everyone in China used only one system of measurement. The definition of a unit of measurement could not shift depending on where or what one was measuring. Unification meant bulldozing local measures, even if these were the units that people were most familiar with. The Nationalist government put its foot down on this front when the Guangdong provincial government appealed to keep the *hu* 斛, a unit of weight equal to 600 grams. In November 1928, after the promulgation of the Metrological System of the Republic of China (July 1928) but before the finalization of the Law of Weights and Measures (February 1929), the provincial government appealed to the national government to allow its population to use a market *jin* equal to 600 grams instead of the definition spelt out in both the 1928 law (1 market *jin*= 500 grams). This would have effectively allowed Guangdong to continue using the *hu* by another name. Although Nanjing denied this request, the authorities in Guangzhou reiterated this appeal in March 1929. Its correspondence with Nanjing patiently explained that in Guangdong, most people used the *hu* which comprised twenty-four *liang*. This meant that in Guangdong, one *liang* was equal to 25 grams. But under the system conceived in Nanjing, one market *jin* was equal to sixteen *liang*. Under this law, one *liang* was equal to 31.25 grams— (slightly) heavier than the Guangdong *liang*. Guangdong's provincial government highlighted that this discrepancy would create the opportunity for

[208] Gongshang bu [Ministry of Industry and Commerce], *Gongshang bu duliangheng tuixing weiyuanhui huiyi huibian* [Compilation of meeting materials of the meeting of the Metrological Reform Implementation Commission of the Ministry of Industry and Commerce], 24-25.

[209] In making this case, Nanjing's officials were very probably wilfully ignoring the fact that the Maritime Customs under men like H.B. Morse had been collating and publishing Chinese trade statistics for years (see chapter one). The Customs had simply been doing so with units which had not been dictated by the Chinese government.

commercial fraud. More broadly, provincial authorities were worried that the national government was not doing enough to prevent the outbreak of commercial panic over erratic or sudden price changes in commodities connected to the shifting definition of units of measurement. Ultimately, the Administrative Yuan decided that the Guangdong *hu* and the Guangdong *liang* had to go. In April 1929, it issued a final order that Guangdong had to comply to the metrological system set in Nanjing.[210] The push for national standardization could not brook a local variant.

THE MEASURE OF METERS: NOT ALL METERS ARE THE SAME

The leaders of metrological reform insisted that Chinese people did not understand or care about varying units of measurement. As they prepared to enforce the new system, reformers in Nanjing insisted that the government had to teach people accuracy and precision. In speeches and discussions, they amplified earlier criticisms about Chinese people's careless imprecision and exhorted local officials and inspectors to take the task of inducting people to accuracy seriously. Xu Shanxiang, a key leader of the GMD's metrological campaign, claimed that the concept of accuracy (*biaozhun*) had never existed in Chinese history although China had long understood justice and honesty (*gongping zhengzhi*).[211] One of his colleagues in the Ministry of Industry and Commerce was even more vehement in his criticism of Chinese society's "common failing" (*tongbing*) to measure anything with precision (*jingque*). According to him, people had a complete disregard for accuracy and often made do with amounts that were "almost" (*chabuduo*)

[210] Guangdong shengzhengfu [Guangdong provincial government], correspondence with Ministry of Industry and Commerce, file 613/304, SHAC.
[211] Gongshang bu [Ministry of Industry and Commerce], "Yanjiang" [Speeches] in *Gongshang bu quanguo duliangheng ju duliangheng jianding renyuan yangchengsuo diyici baogo shu* [First report of the Training Center for Inspectors of Weights and Measures], 8-10.

right.[212] In a speech to the first cohort of trainees at the Training Center, Hu Yuanbo enjoined them to understand the gravity of the task ahead of them. He identified the key battleground for modernizing China as the laboratory where people could learn about the importance of accurate measurement, an essential foundation for the development of science and engineering in the country.[213] In the next year, Zhang Zeyao, speaking to the third intake, reiterated that inspectors had to teach people to care not just about accuracy but different degrees of accuracy.[214] The GMD representative from the Nanjing government Lou Tongsun reiterated that trainees had to teach people what it meant to be accurate (*zhunque*).[215] From Nanjing's perspective, inspectors had to perform the crucial task of inducting people to the concept of accuracy—that there was a difference between 31.35 grams and 25 grams, and that this difference was significant.

Officials in the capital recognized that instruments of measurement were key for achieving this goal. They had to make sure that people used the right kind of instruments, namely those which accurately reflected the system which had been promulgated in 1928 and 1929. After China's official system had been finalized, the Nanjing government commissioned a set of original standards (*yuanqi*) from the International Bureau of Weights and Measures. Only one set existed, and it was preserved in the capital. It served as the standard against which all other types of instruments of measurement were measured. Sets of weights, wooden dippers, and curved rulers were accurate or not based on their closeness to the *yuanqi*. Officials in charge of

[212] Gongshang bu [Ministry of Industry and Commerce], "Biye dianli" [Graduation ceremony] in *Gongshang bu quanguo duliangheng ju duliangheng jianding renyuan yangchengsuo diyici baogao shu* [First report of the Training Center for Inspectors of Weights and Measures], 4-5.
[213] Gongshang bu [Ministry of Industry and Commerce], "Yanjiang" [Speeches] in *Gongshang bu quanguo duliangheng ju duliangheng jianding renyuan yangchengsuo diyici baogao shu* [First report of the Training Center for Inspectors of Weights and Measures], 22-29.
[214] Shiye bu quanguo duliang heng ju [Ministry of Industries, National Bureau of Weights and Measures], *Quanguo duliangheng ju duliangheng jianding renyuan yangcheng suo dierci baogao shu* [Second report of the Training Center of Inspectors of Weights and Measures] (Nanjing: Zhonghua yinshua gongsi, 1931), 108-114.
[215] Ibid., 147-149.

nudging metrological reform forward were particularly anxious that local standards (*difang biaozhun qi*) and inspection instruments (*jianding yong qi*) cleaved closely to the *yuanqi*, and hence, to the official system of measurement. It was important for standards to be accurate because when they were distributed to county and municipal governments, they would serve as local referents to the official system of measurement. All instruments of measurement used by the general public (i.e. most instruments of measurement) were to be verified according to these standards. Imprecise standards would have a knock-on effect on the accuracy of most instruments of measurement within society. The same held true for inspection instruments because they were the tools which inspectors would use to check instruments of measurement. In his radio address before the meeting of the Implementation Commission, Wu appropriated an idiom commonly used by businessmen to explain that a minute variation in key standards would grossly compromise the pursuit of standardization and accuracy: the slightest difference leads to a huge loss (*chazhihaoli, shizhiqianli*).[216]

To meet the tremendous demand across the country, such instruments had to be mass produced. The catch was that mass production was not *identical* mass production. With most products, slight, mostly imperceptible, variations in mass produced items do not constitute a problem to either manufacturers or end users. They are made, brought, sold, and used with no consternation surrounding their variation. This was not true for instruments of measurement, especially standards and inspection equipment. China's metrological laws accommodated unavoidable deviations from the legal units of measurement by recognizing that instruments have

[216] Gongshang bu [Ministry of Industry and Commerce], *Gongshang bu duliangheng tuixing weiyuanhui huiyi huibian* [Compilation of meeting materials of the meeting of the Metrological Reform Implementation Commission of the Ministry of Industry and Commerce], 92.

"errors" (*chashu*) or "allowable tolerance" (*gongcha*).[217] But the allowance was limited; there were maximum allowable errors for different classes of instruments.

Officials in Nanjing were most concerned about the accuracy, and hence the *gongcha*, of local standards (*difang biaozhun qi*), most commonly known simply as standards (*biaozhun qi*). As local referents for the official system of measurement, it would have been ideal if they had all been exact replicas of China's *yuanqi*. But since that was an extreme technical improbability, the government opted for a system to manage the degree to which standards could and did deviate from the official system of measurement. Local standards could only deviate from the units embodied in China's *yuanqi* by only a maximum 20% of the total *gongcha* generally permitted for instruments of measurement.[218] This was a tighter limit than that placed on almost any other class of instruments, essentially mandating that standards would most closely resemble China's *yuanqi*. The Ministry of Industry and Commerce also insisted on delineating the allowable tolerance, or *gongcha*, of each unique instrument in the thousands of sets of standards produced in Beiping as well. Sets of standards (each comprising two rulers, two sets of weights, and a standard liter container) were all accompanied by an Inspection Certificate and User Manual. A draft copy of this document submitted by Chen Jingyong to his superiors in Nanjing captures the serious, careful way officials treated the error of standards. The certificate testified that the set had been assayed by the Bureau and found to be "compliant" (*hege*) with the legal system of measurement, and, additionally, that the tolerance or allowable error (*gongcha*) of these standards were all within 20% of that permitted under metrological regulations. This attestation

[217] Shiye bu quanguo duliangheng ju [Ministry of Industries, National Bureau of Weights and Measures], *Zhongyang ji geshengshi duliangheng fagui huikan* [Compilation of Central, Provincial and Municipal Regulations Regarding Weights and Measures], 8.
[218] Ibid., 61.

was followed by technical specifications for each component, including the unique "actual error" (*shicha*) of each standard. For instance, the certificate sets out the length, shape, allowable error, actual error, and the actual weight of the standard for length in the standard system, a 50-centimeters copper ruler.[219] In all likelihood, the 50-centimeter standard ruler was not exactly 50 centimeters long, and the Nanjing government insisted on meticulously measuring and recording the unique variation from the national standard for each local standard. Similar details were included for other components of the set. Together with the material instruments, documentation on the *gongcha* of local standards, projected the accuracy and authority of China's *yuanqi* around the country.

The instruction manual also contained instructions on how to use and preserve the integrity of the standards. It warned that the standards were all made of copper, a material that was especially prone to oxidation. Besides the appearance of unsightly spots, oxidation could also, crucially, alter dimensions of standards. After this warning, the manual provided careful directions on how to handle the standards when they were used for inspection. Inspectors were supposed to only handle the two rulers with the tips of their fingers, touching only the non-marked ends of the rulers. They were also advised not to breathe directly onto the rulers. The standard copper containers could only be handled with thin, velvet cloths, and, the weights, both the conical ones and the flat square ones, were supposed to be picked up only with the accompanying pair of pliers. The manual also specified the conditions under which the standards had to be preserved.[220]

[219] "Gongshangbu quanguo duliangheng ju difang biaozhunqi jianding shu fu shiyong shuoming shu" [Ministry of Industry and Commerce National Bureau of Weights and Measures Certificate for Local Standards with Instructions Manual], file 613/349, SHAC.
[220] Ibid.

The Ministry also restricted what sorts of agencies or persons could obtain or use standards and other types of instruments of measurement. Standards occupied an intermediate position in a strictly hierarchical system of different class of instruments of measurement. The next class of instruments after the *yuanqi* were the vice-original standards (*fu yuanqi* 副原器), which were preserved by national agencies, and provincial and municipal governments. If other organizations needed to or wanted to obtain their own sets of vice-original standards, they had to request and obtain permission for doing so from the Ministry of Industry and Commerce. The next level of government— county and city governments— could only obtain (local) standards, *difang biaozhun qi* or simply *biaozhun qi*. In contrast, merchant and trade associations, and manufacturers of instruments of measurement were not allowed to own any of these classes of standards. Instead, they were directed to purchase models for instruments of measurement for general use (*minyong duliangheng biaoben qi*).[221] Even though the national government wanted to spread the use of metric units across the country, it insisted on keeping very tight control over physical standards, a key class of instruments which embodied these units of measurement.

The intricacies of this system were not always clear beyond the capital, especially in the early days of the campaign. Authorities in city of Hankou were among the earliest to embrace metrological reform. But in their update to the Ministry of Industry and Commerce in November 1929, it was clear that municipal authorities misunderstood certain aspects of Nanjing's vision for a cascading hierarchy of standards and instruments. The Hankou municipal government expressed concern about how a single factory in Beiping could possibly meet the voluminous demand for big and smaller dippers, rulers, steelyards, weights, and scales throughout China. The

[221] Gongshang bu [Ministry of Industry and Commerce], *Gongshang bu duliangheng tuixing weiyuanhui huiyi huibian* [Compilation of meeting materials of the meeting of the Metrological Reform Implementation Commission of the Ministry of Industry and Commerce], 60-62.

chief of Hankou's Bureau of Social Affairs suggested that Nanjing should consider decentralizing the production of instruments of measurement by allowing private businessmen in different parts of China to meet this demand. Since it was patently impossible for one factory to meet the needs of everyone in China, the Hankou government had taken the common-sense step of beginning to license local businesses to produce instruments of measurement which followed the legal system of measurement. In this report, municipal officials confused standards (*biaozhun qi*) and equipment that most people would use in their everyday lives (*dulianghеng qi*). Given this misconception, it was not surprising that the officials in Hankou dutifully reported that they had arranged for the standards they received to be duplicated (*fangzao*) as quickly as possible.[222] The Ministry's officials in Nanjing explained that standards (*biaozhun qi*) were produced only by the Beiping factory and that ordinary instruments should be mass produced based on models (*biaoben qi*); each of these classes of instruments had their own specialized function. Local businesses were supposed to produce instruments of measurement for general use (*dulianghеng qi*).[223] Half a year later, Nanjing had to reiterate this clarification to county officials in Macheng (Hebei province), explaining that authorities should not interchange these instruments (in this case standards and models) since their functions are essentially different.[224] In these letters, local authorities did not seem to see standards, models, and instruments of measurement in quite the same light as their superiors in Nanjing. For national officials in Nanjing, the original standard (*yuanqi*) for the meter was different from the thousands of meter standards (*biaozhun qi*), each individually numbered, measured, and certified; and, these were in turn different from the

[222] Hankoushi zhengfu [Hankou municipal government], "Chengbao tuixing dulianghеng qingxing you" [Report on Implementation of Weights and Measures], file 613/317, SHAC.
[223] Gongshang bu [Ministry of Industry and Commerce], draft response to Hankou municipal government, file 613/317, SHAC.
[224] "Zi hubei shengzhengfu gongzi sanersanjiu hao" [Directive to Hubei Provincial Government No. 3239], *Gongshang gongbao,* no. 23 (1930): 3.

models (*biaoben qi*) used to churn out a larger volume of instruments for everyday use (*duliangheng qi*). While officials in Nanjing imagined these different classes of instruments occupying a strict, stratified system where their accuracy was guaranteed by the *yuanqi* in the capital, this overall vision was sometimes lost on local officials, especially in the beginning of the campaign.

These different perspectives about what standards were and how tightly they should be controlled led to tensions in the early implementation of the campaign. In Nanjing's view, the crux of the system was a tightly controlled system of production, assay, and re-inspection, especially of standards (*biaozhun qi*) and secondarily of models (*biaoben qi*). Material instruments were essential to metrological reform; the Ministry emphasized that "various classes of standards and instruments of measurement are the *only* tool for standardizing weights and measures."[225] Without such instruments, China's new metrological system would live only as statute. Rulers with the right markings, scales with just the right kind of weights, and containers with certain dimensions were the things which would give life to law. The problem was that the government could not promptly deliver these instruments throughout the country. The Ministry conceded this unsatisfactory state of affairs at the implementation meeting of November 1930.[226]

In response to these logistical challenges, the Ministry insisted on the absolute necessity of the centralized production of some kinds of instruments. The agenda item submitted by the Ministry in November 1930 emphasized that certain classes of instruments, namely standards, models, and inspection equipment, had to be manufactured at a centralized location where it can be ensured that they "strictly adhere" (*ke zunding*) to the legal metrological system. The Ministry

[225] Shiye bu [Ministry of Industries], *Gongshangbu quanguo duliangheng huiyi huibian* [Compilation of materials of the National Weights and Measures Meeting of the Ministry of Industry and Commerce], 11.
[226] Ibid., 19-22.

specifically dismissed the possibility that the production of these critical pieces of equipment could be left to the mayhem of decentralized manufacture. Instead, the Ministry insisted on ironing out some of the issues interfering with the delivery of standards, prototypes, and inspection equipment. It proposed streamlining the red tape surrounding the application for passports with the Ministry of Finance, and negotiating discounted rates for instruments of measurement on privately-run trains.[227] In essence, the Ministry suggested that the whole of government come together to jump through intricate hoops to send centrally-produced standards to provinces, municipalities and counties rather than allow local production of these all-important standards. Within this framework, all sets of standards, models, and inspection equipment would continue to be made only in the Beiping factory.

INSTRUCTING INSPECTORS

The same centralizing concerns marked the Ministry's response to the problem of getting trainees from across China to report for a three-month training program in Nanjing. As outlined above, local authorities who obeyed Nanjing's instructions to call for qualified candidates faced disappointing results. By the November 1930 meeting, officials from Fujian province warned that a shortage of inspectors would seriously hinder the progress of metrological standardization.[228] At the same meeting, their counterparts from Anhui province admitted to facing the same difficulty with getting sufficient numbers of qualified candidates for the training program in Nanjing. Although they had issued a call for qualified trainees, they received no applications from such candidates. They extended the deadline for applications to no avail, and

[227] Ibid.
[228] Ibid., 132-133.

could only scrounge up a single trainee for the first two intakes in 1930 with assistance from the local bureau of education.[229]

One official made a common-sense proposal to address the widespread and serious shortfalls between the number of trainees Nanjing required each province or municipality to send in and the actual number of students who showed up. He suggested that the national government should allow local governments to train their own inspectors on site instead of paying for their travel to and from Nanjing, and their living expenses while they were in the capital.[230] But the Ministry was implacable. In May 1930, it issued a directive bluntly insisting that at the very minimum, there had to be one inspector who had passed the advanced class in the training center in every county to oversee the enforcement of the new system of measurement. All provincial and municipal inspection centers could also only be headed by someone who had this qualification.[231]

From the perspective of many of the Ministry's officials, centralized training was non-negotiable because inspectors (*jianding yuan*) were just as vital to the realization of the new system of measurement as instruments of measurement themselves. The all-important process connecting accurate standards and accurate measurement in any province or municipality was *jianding*. When they used this term, officials involved in metrological reform referred to the technical process of assaying an instrument of measurement to ensure that it accurately reflected specific units of measurement. The Ministry's officials saw this as the primary task of their inspectors stationed throughout the country. Tellingly, they referred to local offices for enforcing

[229] Ibid., 41-42.
[230] Ibid., 149-150.
[231] Gongshang bu [Ministry of Industry and Commerce], "Yanjiang" [Speeches] in *Gongshang bu quanguo duliangheng ju duliangheng jianding renyuan yangchengsuo diyici baogao shu* [First report of the Training Center for Inspectors of Weights and Measures], 6.

this campaign as provincial or municipal inspection centers. Practical inspection was also a heavy emphasis of the curriculum of the Training Center in Nanjing. In fact, it would not be an exaggeration to say that besides finding a way to meet the demand for different types of instruments of measurement, most of the work of metrological reform and administration *was* assaying and re-inspecting instruments of measurement. In the system drawn up in Nanjing, all instruments of measurement for general use (*minyong duliangheng qi*) would exist in an endless cycle of inspection, certification, re-inspection, and re-certification starting at the point of production. The Ministry's metrological by-laws specified that all instruments of measurement had to be inspected and certified as compliant with the legal system before they could be marketed to the general public.[232] After they had passed into general use, they would still be subject to regularly scheduled inspections by local inspectors, and they would pass out of use when they finally failed to be re-certified as compliant with the official system of measurement. Even vice-original standards and local standards had to be periodically checked, once every decade and five years respectively.[233]

For officials in Nanjing, checking the accuracy of instruments of measurement was absolutely essential. The Ministry insisted on it even as local officials explored the possibility of loosening inspection requirements. In November 1930, when local officials complained about a lack of resources for establishing factories to produce instruments of measurement, officials from the Ministry of Industry and Commerce doubled down on its insistence on *jianding*. It specified that all factories across the country had to set aside a dedicated space to inspect their products; factories without such facilities would not be permitted to operate. The same instruction clarified

[232] Shiye bu quanguo dulangheng ju [Ministry of Industries, National Bureau of Weights and Measures], *Zhongyang ji geshengshi duliangheng fagui huikan* [Compilation of Central, Provincial and Municipal Regulations Regarding Weights and Measures], 8.
[233] Ibid.

that it would be illegal to use *uninspected* instruments *even if they conformed to the legal system of measurement*.[234]

The Ministry's hardline commitment and attention to inspection was a key component of the vision for a comprehensive system of managing the errors of instruments of measurement. The Implementation Commission laid down the intricate procedures for *jianding* in September 1930. The instructions issued to inspectors were very detailed. With wooden instruments of volume for instance, inspectors were supposed to begin by visually inspecting the containers for groves, protrusions, or cracks. Then, inspectors were supposed to ascertain the exact capacity of containers by gradually filling them with very dry maize (ripened in the spring) using a funnel with a movable catch. Once the container was full to the brim, the maize was to be poured into a container of set capacity. The procedure was similar for containers made of glass or metal, but inspectors had to use cold water instead, patiently waiting for any bubbles to dissipate before measuring the volume of water. The instructions for checking all other sorts of instruments— from measuring tapes to platform scales— were similarly detailed and finicky.[235]

Inspectors were also instructed to carefully note the allowable tolerances (*gongcha*) of each and all the instruments of measurement they were charged with checking. They had to measure and calculate two different sets of tolerances. First, before beginning to inspect instruments of measurement used by the general public, they needed to check and note the tolerances of their own inspection equipment. Then, they were required to measure the *gongcha* of the instrument they were inspecting too. In the case of wooden instruments of capacity, checked using maize, inspectors had to carefully measure out the difference between the stated

[234] Ibid., 12.
[235] Gongshang bu [Ministry of Industry and Commerce], *Gongshang bu duliangheng tuixing weiyuanhui huiyi huibian* [Compilation of meeting materials of the meeting of the Metrological Reform Implementation Commission of the Ministry of Industry and Commerce], 78-83.

capacity of the container and the actual volume of maize it held, whether this was a shortfall or an excess.[236] Their final certification for each piece of inspected instrument had to indicate both the instrument's tolerance and that of their own inspection instruments. If instruments of measurement were gradated, inspectors had to measure and record the *gongcha* of each marked gradation individually. In practice, all the rhetorical emphasis on accuracy (*biaozhun*) was translated into the meticulous management of error during inspection. This task fell squarely on the shoulders of the growing group of inspectors, and they received very detailed instructions on how to do so. Their curriculum at the training center also focused on these practical aspects of their work. In fact, when the center's leaders were preparing for the third intake, they planned to increase the amount of time dedicated to practical training in tasks like inspection.[237]

At least some of China's inspectors of weights and measures seemed to genuinely believe that they were in the vanguard force for teaching accuracy to society, and that this was a worthwhile project. The inspectors were young men and women. (Although the first intake of the training center was all male, a handful of women were included in the second and third intakes in 1930-31.) Compared their superiors in the Ministry who tended to be significantly older, most inspectors were in their early twenties when they arrived to be trained in Nanjing. At least some of the young people who were drawn into metrological reform seemed quite taken with the idea of teaching China accuracy. A group of particularly enthusiastic students of the training center established the Chinese Society of Weights and Measures (*Zhongguo duliangheng xuehui*) in October 1930.[238] At the national meeting to discuss metrological reform in the following month,

[236] Ibid., 78, 80.
[237] Shiye bu quanguo duliang heng ju [Ministry of Industries, National Bureau of Weights and Measures], *Quanguo duliangheng ju duliangheng jianding renyuan yangcheng suo dierci baogao shu* [Second report of the Training Center of Inspectors of Weights and Measures], 56.
[238] Gongshang bu [Ministry of Industry and Commerce], "Fulu" [Appendix] in *Gongshang bu quanguo duliangheng ju duliangheng jianding renyuan yangchengsuo diyici baogao shu* [First report of the Training Center for Inspectors of Weights and Measures], 7.

the society submitted an item which revealed its members' youthful ambition to generate a widespread change in habits of mind in Chinese society. This agenda item proposed steps to cultivate the concept of "accurate measurement" (*jingque jiliang*) in society. It diagnosed the root cause as a basic carelessness (*hanhu xing*) in the national character, as revealed by the widespread use of phrases like "almost" (*chabuduo*) and "approximately" (*dayue*). For metrological reform to succeed, the government needed to help people develop concepts and habits of accuracy. Resolving this root cause (the lack of a sense of accuracy) would earn people's support for the campaign, and also thwart the activities of those who would undermine this reform. The trainees' proposal for doing so targeted unremarkable items in everyday life like bottles, cups, bowls, and knives. They wanted the government issue guidelines specifying the dimensions for all such goods. Additionally, the dimensions or capacities of such items should be visibly marked at suitable points.[239] By using such items regularly, ordinary people would literally get a feel for what 500 grams should feel like, or how large a 200-milliliter bowl should be. In this proposal, the inspectors self-consciously wrote that even though these things did not seem very significant, working through everyday items was a very real way of teaching accuracy and realizing standardization even without an aggressive campaign.[240]

CONCLUSION: CRIMES AGAINST THE REGIME

The project to ensure that there was only one system of measurement across China lasted into the war and after. The government re-established its National Bureau of Weights and Measures in Chongqing. In fact, in the heat of the war, in 1943, some of the leading officials of

[239] An earlier proposal had the same idea, proposing that China's paper currency and coins should be designed to embody some basic units of measurement so that people would have official weights and measures literally in their pockets.
[240] Shiye bu [Ministry of Industries], *Gongshangbu quanguo duliangheng huiyi huibian* [Compilation of materials of the National Weights and Measures Meeting of the Ministry of Industry and Commerce], 157-159.

metrological reform began discussing plans to expand it into a Bureau of Standards (*Biaozhun ju*) to enforce all sorts of industrial standards. They framed the foregoing efforts to standardize weights and measures as laying essential groundwork for this broader project.

The government in Chongqing also had to deal with activities which sought to undermine the official system of measurement, even as China slid from war to civil war. In 1947, when control of China hung in the balance between the GMD and the CCP, the Ministry of Judicial Administration (*Sifa xingzheng bu*) issued a directive about how subordinate courts should henceforth settle cases involving the contravention of metrological laws which had been passed in Nanjing. It was doing so in response to a complaint by the Ministry of Economics (*Jingji bu*), the parent ministry of the National Bureau of Weights and Measures, that courts were treating cases against the legal system of measurement too leniently. The Ministry referred specifically to two cases which had been decided by the Chongqing District Courts *(Chongqing difang fayuan*) in 1945 and 1946.[241]

In the first case, resolved by the court in May 1945, the court's investigator recommended not bringing charges against two defendants. Each of these men owned shops in Chongqing where inspectors of weights and measures had found instruments which did not comply with metrological laws. Liu Bingrong had a scale in his shop which subtracted two *liang* from every market *jin*. The report from the municipal inspection center noted specifically that this deviation from the legally-permitted error (*gongcha*) was fairly substantial. A scale in Xie Xinghe's shop was similarly defective, shortchanging every ten market *jin* by one and a half market *jin* when the first knob was in use, and every five market *jin* by two market *liang* if the

[241] "Sifa xingzhengyuan xunling di siliuwuqi hao" [Ministry of Judicial Administration order no. 4657], file A504000000F/0039/永久/61/1/001-004, National Archives (Taiwan) (NAT).

second knob was used.[242] Liu's defence was that the particular scale which had been found to be defective had actually been brought in by a vegetable peddler to be modified because it was not working properly; he claimed to be ignorant of the duplicitous nature of the scale. His co-defendant claimed that the defective scale in his shop had been crafted by an (incompetent) apprentice, and had been selected for inspection before he had the opportunity to rectify the mistake. Although he included these statements, the inspector who handed this case to the courts concluded that both men had clearly broken laws and asked the courts to do the necessary.[243]

In the second case, the Chongqing District Court found the defendant Gu Chunting not guilty in February 1946. Gu had been brought to court to face the charge that he had counterfeited official documents (*gongwenshu*) because he had produced two ersatz steel seals, one with the character "同" (*tong*, meaning identical) and the other designed to imprint "一" (*yi*, lit. one, meaning identical). These were identical to the stamps used by local inspectors of weights and measures to certify that instruments of measurement were identical, or acceptably similar, to standards or inspection instruments.[244] The only difference was that the official seals had been produced at the behest of the national government; Gu's seals were a private initiative. The public prosecutor reasoned that in order to successfully charge Gu with counterfeiting official documents, he had to establish that the activity produced harm to others or the public. He noted that in mimicking the seals used by official inspectors, Gu obviously intended to evade (mandated) inspection of his products. However, in his view, the act did not meet the standard of causing harm to others or the public. Moreover, the investigation did not conclusively establish

[242] All of these scales would have allowed sellers to profit by selling less than the weight displayed on the scale. These scales disadvantage the buyer.

[243] "Chongqing shiyan difang fayuan jianchaguan buqisu chufenshu" [Chongqing district court investigator's report recommending no charges], file A504000000F/0039/永久/61/1/003, NAT.

[244] When officials were being designed in 1928-30, there was some concern that these simple characters were too easily copied by unscrupulous businessmen.

that Gu's instruments deviated from the legal system of measurement. Thus, although it was illegal (*weifa*), the public prosecutor reasoned that Gu's actions only warranted an administrative sanction.[245] This was the reasoning behind the court's "not guilty" (*wuzui*) verdict.

Officials from the National Bureau of Weights and Measures were so frustrated with these outcomes that they pushed their parent ministry to issue an extra-judicial commentary on the handling of these cases. The complaint noted that even though both of these cases were closed, and hence, that there was no way to reverse or amend the outcomes, it was imperative that all Chinese courts approach future cases differently. Metrological laws strictly prohibited the production of all non-compliant instruments in order to support metrological standardization. Officials argued that since it had been proven beyond a doubt that Liu had produced such a scale, he should be punished. They noted that this would deter others from similarly deviating from the officially sanctioned set of units of measurement. The letter contained an even greater swell of outrage about the court's acquittal of Gu. In particular, the Bureau's comments objected to the public prosecutor's reasoning that Gu had not caused harm to the public and others by essentially hijacking the authority of inspectors of weights and measures. The Bureau's note warned that if Gu had used his fake seals, he would have led others to falsely believe (*wuxin*) that his instruments complied with metrological laws when they had not been certified as such by the relevant authorities.[246] To the Bureau, it was inaccurate for the prosecutor to have concluded that there had been no harm done to others. This false belief was the harm, and Gu's guilt was undeniable.

[245] "Chongqing difang fayuan xingshi panjue" [Chongqing district court penal judgment], file A504000000F/0039/永久/61/1/004, NAT.
[246] "Sifa xingzhengyuan xunling di siliuwuqi hao" [Ministry of Judicial Administration order no. 4657], file A504000000F/0039/永久/61/1/001-002, NAT.

The Bureau's outrage in response to the outcome of these two cases affirms the twin goals of this campaign. The first was standardization. If all of China was supposed to use one set of units of measurement, then people like Liu and Xie could not be allowed to continue to make and sell instruments which used units other than the ones set out in the relevant regulations. The activities of such manufacturers also hint at precisely the kind of fraud which incensed metrological reformers, and which standardization was meant to guard against. One *jin* was supposed to mean just that, in law, in every instrument, and in every transaction. The second goal was centralization— the government was to have the exclusive right to certify instruments as accurate and compliant with the law. It was this exclusivity which Gu had violated when he copied exactly the kind of seals which inspectors would have used to make this declaration. Such seals took China back to the situation where different authorities— national or provincial governments, different trade associations— exercised the right to set and maintain their own units of management, valid for specific functions like collecting taxes or selling rice, or in limited regions. This was the situation which the Nanjing government wanted to abolish once and for all. Only the national government could have the right to permit the use of instruments of measurement based on whether they adhered to the system of measurement promulgated by the same authority.

CHAPTER 3 STANDARDIZATION AND OTHER HISTORIES OF MEASUREMENT

INTRODUCTION: STANDARDIZATIONS

In 1918, Li Deyu, Lu Donglin, and Wang Zuozhen, three alumni of the First Jiangsu Provincial Agricultural School, published a lengthy article about the *Longquan muma dan*, a system widely used to sell logs in southern China. Using this system, sellers and buyers agreed on the price of logs based on the circumference (*wei*) taken at a certain position along the log using tape measures fashioned out of bamboo splints (*miechi*). Not much else is known about the three authors, but the article reveals an intimate familiarly with the business of selling logs. The appendices logged not just the length of different segments of the eastward transport of logs from mountains to markets, but also included helpful notes like the location of tolls, and areas where traders should take extra care because of treacherous rapids or the perennial presence of bandits in certain areas. They were laying out a historic system of measurement because they felt that it had become an obstacle for the sale of Chinese wood. According to them, the non-standardized units and practices bundled under the label "Longquan muma dan" disadvantaged Chinese lumber in a marketplace where buyers also had the choice of wood from the United States or Japan. These foreign alternatives were sold using standardized units; buyers knew at a glance how much wood they were paying for. The *Longquan muma dan* was not so transparent. The numbers on invoices for logs sold in southern China did not reflect only the dimensions of the logs. Li, Lu, and Wang argued that the whole sector should replace the *Longquan muma dan* with the globally legible cubic *chi* (*lifangchi*) to level the playing field.[247] They were most likely referring to the cubic meter. Yet, in the 1930s, inspectors of weights and measures found it

[247] Deyu Li, Donglin Lu, and Zuozhen Wang, "Shang xinhe muye qingxing [State of timber sector in upper Xinhe [Hebei province]]," *Jiangsushengli diyi nongye xuexiao xiaoyouhui zazhi* [Alumni Magazine of the First Jiangsu Provincial Agricultural School], no. 4 (1918): 33-53.

difficult to sell the legal system of measurement to sellers of logs. They were one of the stubborn hold-outs, including in areas where inspectors enjoyed relatively great success in getting people to switch to the new system of measurement.[248]

Whereas sellers of wood made no progress on using the legal system of measurement, merchants in Xiamen, a city in the southern province of Fujian were chided by local and national authorities for moving too quickly on metrication. In 1933, the Merchant Association of Xiamen held multiple meetings to discuss the problem of embracing the market system. It was particularly difficult to get local businessmen to use units of weight in the market system (*shiyong zhi*). These units were half those in the standard (metric) system (*biaozhun zhi*), and local businessmen complained that they were too small compared to the units they were familiar with. After several meetings, the association resolved to use the standard system instead. Its bigger units of weight (twice the size of those in the market system) resolved the specific concerns of the local business community. Xiamen's merchants were sure that their plan was unobjectionable since the standard system was China's official system of measurement, and the market system existed only to serve the cause of metrication in China. They were so certain of this that when provincial authorities rejected their plan, they asked the National Bureau of Weights and Measures to reverse the provincial proscription. The Bureau's response might have perplexed them—national authorities expressed puzzlement that the market system did not suit Xiamen's merchants since it had been widely adopted for commerce in so many parts of China. The national office spearheading metrication in China told Xiamen's businessmen that they

[248] "Geshengshi tuixing jinkuang" [Recent developments in enforcement in provinces and municipalities], *Duliangheng tongzhi*, no. 3 (Oct 1932): 6.

could not immediately embrace the metric system; they had to take the detour through the market system.[249]

As these glimpses suggest, metrological reform did not go entirely to plan in the 1930s. Although the national three-phase timetable projected complete national metrological standardization by the end of 1933, the roll out of the legal system of measurement lasted beyond this point. Enforcement was hamstrung by inadequate financial resources, and factional rebellions disrupted or reversed early progress in some provinces. Local inspectors of weights and measures and communities were even attacked by soldiers who apparently objected to metrological reform.[250] But the most common problem, and the one which absorbed most of the energies of officials, was that certain groups refused to use the new system of measurement. Some groups, like sellers of logs, simply shrugged off metrological reform, choosing to stick to their non-standardized bamboo tape measures and the cumbersome *Longquan muma dan*. Others, like the merchants in Xiamen, appealed against the units or instruments they were asked to use. If officials had focused on the production and dissemination of new instruments of measurement in the preceding preparatory phase (1929-30), the 1930s taught them the hard lesson that an adequate supply of new instruments did not lead naturally to embrace of the new system of measurement. In the 1930s, much of their work revolved around coaxing or even forcing people to give up what were then illegal instruments and practices. This was an infinitely more difficult task. To do so, officials had to understand why sellers of logs and salt, owners of silverware shops (*yinlou*), and people who sold small scoops or pots of oils and alcohols did not want to use the new system of measurement. Once they identified these root causes, the Bureau

[249] "Zhongyang dulianghеng xingzheng xiaoxi" [Updates on central weights and measures administration], *Dulianghеng tongzhi*, no. 7 (Oct 1933): 2-3.
[250] "Dulianghеng xingzheng xiaoxi" [Updates on Enforcement of Weights and Measures], *Dulianghеng tongzhi*, no. 4 (Dec 1932): 6.

took steps to facilitate these groups' transition to the new system, with varying degrees of success.

In this chapter, I examine how agents of the Bureau did their work, and how different groups responded to their efforts to standardize units of measurement throughout China. Officials' decisions and actions clarify the Nanjing government's metrological agenda. In the 1930s, it became increasingly clear that the GMD government in Nanjing wanted to enforce *compliance* with the legal system of measurement and the national timetable for metrication. Officials pursued this very narrow objective even as metrological communities grappled with their own separate concerns about standardization, convenience, and precision which were not addressed by Nanjing's metrological reform. In reality, Nanjing's single-minded pursuit of the thin goal of national standardization was only one of the many histories of measurement playing out in Republican China. By looking closely at the strategies pursued by Nanjing's officials and the mixed results, I highlight that the government was better able to foist the new system of measurement onto tight rather than loose metrological communities.

MILES TO GO: METROLOGICAL REFORM IN THE 1930S

The government made significant progress establishing the bureaucratic apparatus it needed to introduce and enforce the official system of measurement across the country in the early 1930s. Although the country as a whole was running behind on the national timetable for achieving metrological standardization, provincial and municipal authorities were gradually acting on their duty to enforce national metrological law. The provinces and cities scheduled to complete standardization by the end of 1931 (phase one) led the way. When the National Bureau of Weights and Measures conducted a nationwide survey to check the progress of the campaign in 1932, they received some heartening results, especially from China's eastern provinces. The

government in Jiangsu province for instance had inaugurated their provincial inspection center (*sheng duliangheng jiangding suo*) in August 1931. Provincial authorities had managed to train fifty-nine third-class inspectors locally, and the province's total of eighty-seven inspectors staffed a constellation of fifty-six branch inspection centers (*jianding fensuo*) serving the province's sixty-one counties.[251] Neighboring Zhejiang's scorecard was roughly equivalent: its provincial inspection center was the headquarters of an administrative network comprising eighty-six first-, second- and third-class inspectors, and seventy-two branch inspection centers serving seventy-five counties.[252] Shandong province to the north outdid them both. By 1932, there was a branch inspection center in each of its 107 counties, and the province counted 270 inspectors in its metrological administration.[253]

The 1932 survey also revealed disappointing lags. In areas where local authorities had yet to reach the critical milestone of training sizable numbers of third-class inspectors, no progress was made on establishing branch inspection centers. This was the case in Anhui and Jiangxi provinces.[254] Inland Hunan province was in an intermediate position. It was in the process of growing its pool of third-class inspectors and had established branch inspection centers in twenty of its seventy-five counties.[255] Provinces to the west originally scheduled to achieve standardization in 1932 or 1933 were understandably a few steps behind in this process since officials started acting on the reform at a later date as per the schedule. But returns for the survey indicated that local governments in western China were following in the footsteps of their counterparts in the east— there was a smattering of provincial inspection centers (in Guizhou,

[251] "Quanguo dulianghengju zuijin gongzuo qingxing" [Overview of recent work of the Bureau of Weights and Measures], *Duliangheng tongzhi*, no. 3 (Oct 1932): 5.
[252] Ibid.
[253] Ibid., 6.
[254] Ibid., 5.
[255] Ibid., 5-6.

Shaanxi, Ningxia, Rehe, and Chaha'er provinces), and many local governments had sent trainees to the Training Center in Nanjing. (By 1932, only Qinghai and Xikang provinces had sent no trainees to Nanjing.)[256] Overall, the survey showed a reform creaking on, albeit more slowly than anticipated.

Local officials also reported that they were making real, though uneven, progress getting people to use the new types of approved instruments of measurement. Two intersecting asymmetries marked these early reports. First, inspectors found more success in, rather than outside, cities. Second, local officials found it easier to get people to use new units and instruments of length; in various regions, inspectors found either instruments of weight or volume to be sticking points after they had standardized units and tools for the measurement of length. Nanjing and Shanghai, centers of political and economic power, reported almost complete success with metrological standardization by 1932. Local officials were conducting mop-up campaigns: officials in Nanjing were trying to get a last few uncooperative groups to switch to the new system, and officials in Shanghai informed the Bureau that one of the few obstacles they faced was enforcing the new system in the International Settlement.[257] Local inspectors in both Jiangsu and Hebei provinces reported that metrological standardization was complete in all provincial cities; in counties, inspectors had only achieved success with pushing new units and instruments of length.[258] These trends held further inland in areas included in the second phase of the three-phase national scheduled for metrological standardization. Inspectors

[256] Ibid., 6-7.
[257] "Geshengshi tuixing jinkuang" [Recent developments in enforcement in provinces and municipalities], *Duliangheng tongzhi*, no. 3 (Oct 1932): 6.
[258] Ibid., 5-6.

in Shaanxi and Ningxia provinces reported success in standardizing instruments of length and weight only in provincial cities.[259]

While the metrological revolution was far from complete, by 1934, leaders in the Ministry of Industries (*Shiyebu*), the successor to the earlier Ministry of Industry and Commerce (*Gongshang bu*), felt that metrological standardization had advanced to such a degree that it was time to take the next step of establishing industrial standards (*gongye biaozhun*). In that year, the Ministry dusted off an earlier interest in formalizing industrial standards and took preparatory steps to transform the National Bureau of Weights and Measures into the National Bureau of Industrial Standards.[260] The Ministry's predecessor, the Ministry of Industry and Commerce, had convened a Chinese Industrial Standard Committee (*Gongye biaozhun weiyuanhui*), comprising six sub-committees focusing on different economic sectors, in 1931.[261] The Committee was tasked to guide the Bureau in the monumental task of establishing standards for everything from units for selling electricity to the size and weight of bricks. But this initiative was left on the back-burner as the Ministry and the Bureau focused on the more foundational problem of non-standardized weights and measures. Between 1931 and 1934, progress on this initiative was limited to the collection and translation of foreign industrial standards.[262] In 1934, there was an energetic re-commitment to this project because of the progress which had been made towards the standardization of weights and measures.

Minister of Industries Chen Gongbo's preface to the inaugural issue of *Industrial Standards and Weights & Measures* (*Gongye biaozhun yu duliangheng*), published in July 1934,

[259] Ibid., 6-7.
[260] "Zhongyang duliangheng xingzheng xiaoxi: Guanyu Quanguo dulianghengju fangmian" [Updates on central weights and measures administration: Regarding the National Bureau of Weights and Measures], *Duliangheng tongzhi*, no. 9 (Apr 1934): 5.
[261] Gongbo Chen, "Fakan ci" [Preface], *Gongye biaozhun yu duliangheng* [Industrial Standards and Weights & Measures] 1, no. 1 (Jul 1934): 3.
[262] Yinfu Liu, "Fakan ci (er)" [Preface (two)], *Gongye biaozhun yu duliangheng* 1, no. 2 (Aug 1934): 1-2.

explained that metrological standardization and the drafting of industrial standards were respectively the first and second steps towards an industrialized China. Each of them resolved the two fundamental obstacles holding back industrialization in China. The first problem was that efforts to industrialize China had thus far been divorced from the realities of Chinese society. By this he meant that it had been impossible or extremely challenging to collect economic statistics (*tongji*). The people whom the government had charged with this unwieldy task complained that the work was all but impossible without standardized weights and measures. Fluctuating definitions of the *mu*, the unit used for measuring the size of plots of land, seriously hindered attempts to gauge agricultural productivity, and the instability of units like the *chi* made it difficult to grasp the amount of cloth that was being produced in different parts of China. This unknowing meant that industrial enterprises were unmoored from reality, almost always guaranteeing their failure. The move towards a single set of units of measurement was meant to help the government come to grips with the actual conditions (*shiji de qingxing*) in China. The second problem identified by Chen was inefficiency. Operations everywhere in China, from farms to factories, were not organized to minimize costs. The inflated costs became uncompetitive prices for Chinese goods. Consequently, local goods could not even gain a foothold against foreign products produced in China (in factories run by foreign firms). Industrial standards were meant to address this second problem. Once the government could regulate everything down to the size of screws, economic activity would be streamlined or rationalized (*helihua*).[263] Rationalization was a north star for Chen and his colleagues and subordinates. When Liu Yinfu, an official involved in metrological standardization, wrote a second preface for *Industrial Standards* in its second issue, he also expressed similar ideas. In his

[263] Chen, "Fakan ci" [Preface], 1-3.

view, the dominant economic position enjoyed by industrialized countries over non-industrialized ones was built on a fastidious commitment to "less is more." His shorter preface connected the industrial wealth of Germany to the fact that its government had drastically reduced the types of stationery paper from more than forty to just three standardized sizes. The US, another industrial juggernaut, had reduced an existing variety of thirty-nine bricks to just one. Rationalization lay behind such feats as Ford's international success, the early fulfillment of the targets of the Soviet Union's first Five Year plan, and Japan's success on the economic global stage.[264] The Ministry's current push towards industrial standards set China on the same course towards efficiency and industrialization.

But even as it embarked on this second step, the Bureau did not turn away from enforcing the legal weights and measures. There were constant reminders of the fact that metrological standardization was still more aspiration than reality, even in the parts of China where local inspectors were most effusive about the progress they were making. In early 1933, the National Bureau of Weights and Measures received an appeal from the owners of two factories located in Jiangsu and Zhejiang provinces which cast doubt on the rosy reports from local inspectors. The appeal asked national authorities to ensure that the official system of measurement was being enforced *more* strictly in these areas. These businessmen suspected that not everyone in these provinces was using the new system of measurement because they could not seem to move their stocks of brand new, approved instruments of measurement.[265] Like the 1934 appeal from Xiamen's merchants for permission to use metric units of weight, this request pokes holes in the insistence from local officials that metrological reform was overwhelmingly successful.

[264] Liu, "Fakan ci (er)" [Preface (two)], 1-2.
[265] "Zhongyang duliangheng xingzheng xiaoxi" [Updates on central weights and measures administration], *Duliangheng tongzhi*, no. 5 (Apr 1933): 3.

But there were more indications that much work remained to be done beyond such stray counterpoints to official reports. Wu Chengluo, who was reappointed as the head of the National Bureau of Weights and Measures in late 1932, personally observed the incompleteness of metrological standardization on a series of tours to various cities and provinces. Wu was a zealot for metrological reform, scientization (*kexuehua*), and, subsequently, the push to establish industrial standards in China.[266] On one of his excursions to check the state of standardization beyond Nanjing, Wu noticed that use of the official system of measurement was desultory at best on roads and railways: distance markers, and fare tables displaying the price of transporting cargo used a mixture of metric and non-metric units. Upon his return to Nanjing, the Bureau issued a request for the Ministry of Transport to ensure that adherence to the official system of measurement was absolute across all transportation networks. Based on the shortcomings observed by Wu, the Bureau of Highways was instructed to consistently use the legal nomenclature for metric units on mileage signs, and railway companies were told that metric units had to replace the current mixture of English *li*, the Chinese *li*, and the English pounds and tons on their fare tables.[267]

Wu surveyed the state of metrological reform at his destinations with the same level of attention. He set off on the first of his tours to nearby Shanghai and Hangzhou (from Nanjing) in late September 1932, only days after retaking the top position in metrological administration. In Shanghai, Wu observed that many businesses were indeed in possession of the new types of instruments of measurement, but he cautioned that this did not mean they used these instruments

[266] Chengluo Wu, "Duliangheng zai xianfai shang zhi diwei" [The status of weights and measures in the constitution], *Duliangheng tongzhi* [Weights and Measures Companion], no. 9 (Apr 1934): 1-3.
[267] "Zhongyang duliangheng xingzheng xiaoxi: Guanyu Quanguo dulianghengju fangmian" [Updates on central weights and measures administration: Regarding the National Bureau of Weights and Measures], *Duliangheng tongzhi*, no. 8 (Jan 1934): 5.

consistently or exclusively. In fact, he suspected that people who had dealings with agencies collecting taxes or the Maritime Customs were at least using old and new instruments concurrently because those agencies had yet to switch to the new system of measurement. In short, he suspected that people bought the new instruments of measurement primarily to satisfy pesky inspectors of weights and measures who turned up with an obsessive fixation about finding just the right kinds of instruments.[268] The situation was much the same in his next stop, Hangzhou. Wu recorded that even though purveyors of tea, medicine, and ham told him that they had made the metrological switch, they actually used both old and new instruments. Wu's notes about Hangzhou contain another astute observation. He noted that ownership and/or use of the new instruments of measurement was most widespread and consistent among large shops in commercial districts, precisely where it was most impossible to hide from announced inspections or unannounced spot checks. But even token compliance to the new system was hard to find in smaller markets. The new metrological order had not seeped into the private sphere of the home either.[269] The situation in Beiping, a stop on Wu's second observation tour in winter 1932-33, was similar. Bigger shops along bustling streets had apparently switched to the new system of measurement, but compliance hovered around 30-40% everywhere else.[270]

Wu was not the only official who noticed that the metrological revolution was incomplete. Reports from local officials echoed the problems Wu observed on his tours. Between early October to the middle of November in 1932, Shanghai's inspectors conducted a

[268] In some situations, even the possession and consistent use of new kinds of instruments of measurement did not mean adherence to the official system of measurement. In 1934, the Bureau told officials at the Hankou Municipal Inspection Center that they simply had to ensure that those who sold coal in the city using the new steelyards had to hold them level, not slanted (to change the units being used).
[269] "Duliangheng xingzheng xiaoxi" [Updates on weights and measures administration], *Duliangheng tongzhi*, no. 4 (Dec 1932): 5.
[270] "Difang duliangheng xingzheng xiaoxi" [Updates on local weights and measures administration], *Duliangheng tongzhi*, no. 5 (Apr 1933): 13-14.

comprehensive inspection around the city to ensure that people were using the right instruments of measurement in every district. During this round of inspections, inspectors ferreted out about 600 "old instruments" (*jiuqi*) which were being used by roughly the same number of businesses around the city. Shanghai's commercialized southern district accounted for roughly half of all the rule-breaking: inspectors found 343 businesses using 364 old instruments in that neighborhood.[271] Inspections in Jinan, the provincial capital of Shandong province, the next year also uncovered instances of non-compliance.[272] Between October and November 1933, a city-wide spot check in Beiping uncovered about a hundred old instruments of length, and more than 300 old instruments of weight. The report on this round of spot checks conducted in October-November 1933 suggest that there was a protracted tussle over the use of old instruments between local inspectors and the city's residents. Inspectors continued to conduct subsequent waves of checks until January 1934 to prevent relapses to old instruments and units.[273] Given this state of affairs, it was not surprising that the Bureau received reports of and requests for guidance on how to deal with situations where people only paid lip service to the new system of measurement (*yangfeng yinwei*).[274]

One detailed status update from Nanjing in early 1934 substantiated Wu's claims about the particular limits of metrological reform. The case of how slowly *chengyi* shops (*chengyi dian*) in Nanjing embraced new units of length bears out Wu's observation that compliance with

[271] "Tongji: Shanghaishi dulianghengjiandingsuo zhuyue shouli jianding dulianghengqi tongji" [Statistics: Statistics of instruments of measurement assayed by the Shanghai Municipal Inspection], *Dulianghengtongzhi*, no. 6 (Jul 1933): 19-20.
[272] "Zhongyang dulianghengxingzheng xiaoxi: Guanyu Quanguo dulianghengju fangmian" [Updates on central weights and measures administration: Regarding the National Bureau of Weights and Measures], *Dulianghengtongzhi*, no. 8 (Jan 1934): 7.
[273] "Difang dulianghengxingzheng xiaoxi" [Updates on local weights and measures administration], *Dulianghengtongzhi*, no. 9 (Apr 1934): 26.
[274] "Zhongyang dulianghengxingzheng xiaoxi" [Updates on central weights and measures administration], *Dulianghengtongzhi*, no. 5 (Apr 1933): 4-5.

the new system was mainly a matter of public practice. Nanjing's *chengyi* shops sold ready-made clothing which had been sewn in private homes. While local inspectors had been able to meet with and explain the necessity of switching to new rulers and tape measures to the employees of factories producing thread, belts or military uniforms, they could not do the same with the decentralized contractors (i.e. people in homes) supplying *chengyi* shops. Because this supply chain bridged private and corporate spaces, and the former was proving elusive for reformers, *chengyi* shops continued to use a mixture of old and new units of length for longer than almost any other sector. Inspectors in Nanjing also launched a campaign of attrition against the use of old steelyards and weights in the city's markets. In early 1934, they conducted several rounds of unannounced spot checks (*micha*) accompanied by military police to root out old instruments of measurement. The overwhelming majority of rule-breakers were vegetable sellers and peddlers. In this offensive, inspectors confiscated more than 2,000 old steelyards from stall-holders and peddlers which they broke or destroyed on site.[275]

OUT OF ORDER: SALT MERCHANTS AND SILVERWARE SHOPS

Given the uneven and slow progress of the campaign, the 1930s was a busy decade for the officials at the Bureau and local inspectors. One of the biggest problems they tackled was the reality that not all government agencies stood four-square behind the official system of measurement. When the Commission for the Implementation of Weights and Measures hammered out a national plan for metrological standardization in November 1929, it ordered all government agencies to set a good example for the rest of society by embracing the standard (metric) system by the end of 1930, a full year before any administrative region was due to

[275] "Difang duliangheng xingzheng xiaoxi" [Updates on local weights and measures administration], *Duliangheng tongzhi*, no. 9 (Apr 1934): 19.

complete the switch to the new system of measurement.[276] The most egregious violator of this directive was the Ministry of Finance (*Caizheng bu*). After 1930, it continued to collect taxes using the old imperial-era units of measurement. This included the salt tax (*yanshui*), an important tariff collected in many parts of the country. As inspectors of weights and measures worked to promote the new system of measurement in the 1930s, salt merchants across China were caught between two metrological regimes, each enforced by agents of the state. Inspectors of weights and measures were asking them to use units of measurement which were different from those used to calculate and collect taxes. Merchants in different regions chafed against this extra burden; they only wanted to weigh once. Inspectors stationed in different parts of China reported that salt merchants refused to budge from units they were already familiar with, and which were also being used to calculate the taxes they had to pay.[277] In fact, at one point, Beiping's inspectors reported that the officials collecting the salt tax resisted using new units of weight even after they managed to pressure private salt merchants into making the switch.[278]

Employees of the Maritime Customs, another agency under the purview of the Ministry of Finance, also ignored the 1930 deadline to switch to the legal system of measurement. Customs officers still conducted business using mainly English units of measurement. As with the case of the salt tax, the gap between the units used at the customs and those prescribed by inspectors of weights and measures gave merchants wriggle room to justify metrological inertia. In 1933, inspectors in the city of Qinghai reported that metrological standardization was complete save for some merchants' stubborn insistence on using the same kind of platform scales

[276] Gongshang bu [Ministry of Industry and Commerce], *Gongshang bu duliangheng tuixing weiyuanhui huiyi huibian* [Compilation of meeting materials of the meeting of the Metrological Reform Implementation Commission of the Ministry of Industry and Commerce], 21-22.
[277] "Zhongyang duliangheng xingzheng xiaoxi: Guanyu Shiyebu fangmian" [Updates on central weights and measures administration: Regarding the Ministry of Industries], *Duliangheng tongzhi*, no. 6 (Jul 1933): 3.
[278] "Difang duliangheng xingzheng xiaoxi" [Updates on local weights and measures administration], *Duliangheng tongzhi*, no. 5 (Apr 1933): 13-14.

(*taicheng*) used by the Maritime Customs.[279] In the same year, rice and bean merchants in Shanghai asked the municipal inspection center to grant them exemption from the official system of measurement because they had to work with customs officers to export their product. Since the latter were still using pound scales, merchants would have to take the trouble to convert between English and metric units if they agreed to measure using the official system of measurement. They made it clear that they were protesting the double metrological burden, and not the official or metric system— they promised that they would use the new system of measurement when it became the policy at the Maritime Customs to use it too.[280]

When officials in the Bureau received such reports, they told local inspectors that they simply had to insist on the official system of measurement. However, they understood that commitment to metrological reform had to come from the top. The Ministry of Finance's refusal to adopt new units of measurement did not just mean that the government was failing to lead by example; it was obstructing the spread of the new system of measurement by giving mercantile groups an unassailable argument for why they should be allowed to use existing units of measurement. Officials from the National Bureau of Weights and Measures appealed to the Ministry of Finance to adopt the new units of measurement in the calculation and collection of taxes. This effort intensified between 1931 and 1933 as the Bureau received a steady drip of reports which singled out tax collection and the customs as stubborn obstacles for metrological standardization.[281] By 1933, officials of the Bureau were so frustrated that they explained to

[279] Ibid., 13.
[280] "Zhongyang dulangheng xingzheng xiaoxi: Guanyu Shiyebu fangmian" [Updates on central weights and measures administration: Regarding the Ministry of Industries], *Duliangheng tongzhi* [Weights and Measures Companion], no. 6 (Jul 1933): 3.
[281] Ibid.

inspectors that this plan of action had stalled because their counterparts in the Ministry of Finance would not even agree to a meeting to discuss the issue.[282]

In the 1930s, the Bureau also had to iron out difficulties which had been baked into the national plan for implementation. The plan endorsed in 1929 put the onus for realizing the new system of measurement on local governments, most critically provincial and municipal governments. This meant that enforcement would be coordinated within provinces or cities. In contrast, the plan did not guarantee coordination of metrological administrative efforts *between* different provinces or cities. In most cases, the arrangement seems to have worked well enough. However, this plan of action failed to be effective when officials dealt with sectors in which businesses were closely linked to those in other provinces or other cities. In these situations, national and local officials found that they had to patch[283] the national plan for standardization by knitting together the enforcement efforts in different provinces or municipalities.

This dynamic played out in a type of business called *yinlou* in areas around the major city of Shanghai. *Yinlou*s, literally silver (*yin*) shops (*lou*), were predecessors of modern jewelry shops. By one scholar's reckoning, the hundreds of *yinlou*s in 1920s Shanghai employed about 2,000 skilled craftsmen, mostly from Ningbo (Zhejiang province). These artisans, trained via apprenticeships, crafted fine jewelry (*shoushi*) or luxury household utensils (*qimin*) using gold or silver.[284] Their raw materials also routinely included existing pieces of jewelry sold by individual

[282] "Zhongyang duliangheng xingzheng xiaoxi: Guanyu Quanguo dulianghengju fangmian" [Updates on central weights and measures administration: Regarding the National Bureau of Weights and Measures], *Duliangheng tongzhi*, no. 6 (Jul 1933): 8.
[283] The definition in computing
[284] Nansheng Peng, "Quanli haishi lizhong: 1922 nian Shanghai yinlouye bagong fengchao de quxiang" [Which is More Important, Power or Interests: Orientation of Shanghai Banking House Strikes of 1922], *Zhejiang xuekan*, no. 4 (2008): 54. (Note: The translation of *yinlou* 銀樓 as "Banking House" was provided either by Peng or the journal's editorial team. This is a clumsy to inaccurate translation given Peng's own definition that "*Yinlou*s were a traditional handicraft sector mainly dealing in modifying gold and silver jewelry." (p. 54) For a better sketch of the mixture of native and foreign banking institutions operating in twentieth-century China, see Austin Dean, *China and the End of Global Silver, 1873-1937* (Ithaca: Cornell University Press, 2020), 119-20.)

customers to the *yinlou* in exchange for various currencies.[285] Customers could also get workers at *yinlou*s to modify metalware, for instance through gilding (*baojin*; lit. to wrap in gold).[286] One newspaper article detailing an armed robbery at a *yinlou* (quite common occurrences) in 1923 listed that the three robbers (with northern accents) made off with paper currency, twenty-nine bags of old jewelry, two pure gold watch chains, an assortment of gold watch components, and thirteen pure gold hairpins.[287] [288]

Workers in a *yinlou* conducted transactions based on weight. They weighed silver- and goldware with scales, or steelyards and weights. Shou E, the author (writing under a pen name) of a sardonic essay criticizing the unscrupulous tactics used to dupe customers in *yinlou*s, emphasized the centrality of these instruments and the act of weighing out jewelry or utensils in these establishments. Shen opened his essay "At the *Yinlou*: How can one not lose out?" with a vivid description of silverware shops nestled among tall, western-style buildings and the glittering electric lights of Nanjing Road in Shanghai. Readers follow fashionable women (buying), and desperate, unemployed men (selling) into a *yinlou* along this major commercial thoroughfare. While every other business had times of profit and loss, the *yinlou* always made money. According to Shou, the unnatural profitability of *yinlou*s was artfully guaranteed by a variety of deceitful tactics. *Yinlou*s locked in their gain for instance by selling jewelry which was less fine (i.e. containing smaller quantities of pure silver or gold) than the pieces sold to them, or by adding a certain amount of nickel, a cheaper metal, in the production of silver cutlery. More

[285] Note: Unlike at pawnshops (*danghu* 當戶), customers at the *yinlou* were not entitled to buy back these pieces by repaying a loan.
[286] "Zi Shanghaishi zhengfu gongzi di qiqisanyi hao" [Guidance to Shanghai Municipal Government Directive], *Shiye gongbao*, no. 135-136 (1933): 6-8.
[287] In the 1930s, one appeal on behalf of owners of *yinlou*s in Jiangsu province blamed a drastic deterioration in the fortunes of *yinlou*s partially on the trend of women adopting the short bob, thereby decimating demand for hairpins.
[288] "Qingyun yinlou beijie xiangqing" [Details about robbery at Qingyun silverware shop], *Minguo ribao*, 1923, May 24, 3.

importantly, there was an assortment of tricks surrounding the act of weighing. This crucial task took place at the shop's counters which were always built abnormally high so that the *yinlou*'s employees towered over their customers. Then, from this superior position, workers raise the steelyard (further still) above the eye level as they weigh the pieces to be bought or sold. The customer, observing from below, perceives the two ends of the steelyard as level, not realizing that they are getting the short end of the stick. In reality, the weight assigned to the item through this procedure was usually a little (almost imperceptibly) less than the actual weight of the piece. In this way, the rigged set-up accrues profit for the *yinlou* because it gains a few *liang* of gold for free per day.[289]

When inspectors of weights and measures started to roll out the new system of measurement, they directed *yinlou*s to replace their scales, steelyards, and weights with new ones which reflected the official system of measurement. The owners of *yinlou*s in and around Shanghai did not heed these instructions. In 1932, inspectors in Shanghai reported to the National Bureau of Weights and Measures that they were facing trouble getting *yinlou*s to abandon the old scales.[290] Between 1932-1934, inspectors in Nanjing persistently reported that silverware shops in the capital refused to use the new system of measurement.[291] In surrounding Jiangsu province, authorities also complained that not all *yinlou*s in villages and towns across the province used the right kind of instruments of measurement. The owners of *yinlou*s asserted the centrality of instruments of weight in their operations and explained that they were worried that abrupt changes in the units of measurement would provoke disputes, most critically over prices,

[289] E Shou, "Zai yinlou zhong: Ruhe keyi buzhi chikui?" [At the *Yinlou*: How can one not lose out?], *Changshi* [Common Knowledge] 1, no. 84 (1928): 334.
[290] "Shiyebu zhiling gongzi siqiwuer hao" [Ministry of Industries Directive no. 4752], *Shiye gongbao*, no. 83-4 (1932): 19-20.
[291] "Difang duliangheng xingzheng xiaoxi" [Updates on local weights and measures administration], *Duliangheng tongzhi*, no. 5 (Apr 1933): 13; "Difang duliangheng xingzheng xiaoxi" [Updates on local weights and measures administration], *Duliangheng tongzhi*, no. 9 (Apr 1934): 19.

with customers. The Bureau's uncomprehending response to such appeals was that the national plan for metrological standardization already contained the instructions for how to proceed: inspectors should survey the existing units in use, create and distribute conversion tables between the old units and the new ones, and get business owners to purchase and use new instruments of measurement.[292] If local inspectors followed each of these steps, there would be a smooth transition to the new system of measurement. Of course retail prices would shift if units of measurement were re-defined, but simple tables of conversion would bridge this gap for sellers and buyers. This difficulty had been foreseen and settled in the national plan for standardization.

But there was more to the worries of owners of *yinlou*s than that. One appeal from Yangzhou county (Jiangsu province) explained that the problem was one of coordination, within and beyond the province. What really worried owners of silverware shops was that some shops had persisted with old instruments while others heeded official directives to use new types of weights and measures.[293] This lack of coordination created confusion about the cost of gold- and silverware according to units of weight. More importantly, silverware shops in Shanghai had yet to adopt the new instruments of weight, and Shanghai loomed very large in the operations of *yinlou*s in the region surrounding that city, including Jiangsu province, in at least two ways. First, prior to the meddlesome interventions of Nanjing, metrological order for silverware shops in the region had been set in Shanghai. The instruments of weight in *yinlou*s in Yangzhou county were *identical* to those in Shanghai.[294] This was still the case. The Shanghai standard secured the definition of the units of weight which were crucial for the business of buying and selling gold and silver ornaments and utensils by weight. Second, Shanghai set the standards for the buying

[292] "Shiyebu zhiling gongzi siqiwuer hao" [Ministry of Industries Directive no. 4752], 19-20.
[293] "Zi Shanghaishi zhengfu gongzi di qiqisanyi hao" [Guidance to Shanghai Municipal Government no. 7734], *Shiyebao*, no. 135-36 (1933): 6-8.
[294] Ibid., 8.

and selling of gold and silver in this line because it served as a clearing house. *Yinlou*s in the region tended to draw on the larger reserves of *yinlou*s in Shanghai to stabilize their financial standing. In 1930 when the price of gold was skyrocketing, *yinlou*s in nearby Anhui province were inundated with customers wanting to sell gold jewelry. Naturally, there were few buyers for gold pieces since they were suddenly so expensive. Because it seemed imprudent to hold most of their assets in gold bullion at a time when its price was so volatile, the four biggest *yinlou*s in Anhui reported that in order to stabilize their financial standing, they encashed the pieces of jewelry they bought in Shanghai on the day of receipt.[295] In this way, Shanghai was a center for the trade in gold and silver ornaments in the same way that it served as a hub for the flows of paper and metal currencies which were the lifeblood of commerce before the Nanjing government's monetary reform of 1933.[296] Given the centrality of Shanghai, the owners of *yinlou*s in Jiangsu were not objecting to replacing their weights and measures with new ones; they just wanted to be sure that they were using the same ones as those used in *yinlou*s in Shanghai. Since metrological standardization was being enforced in Shanghai and Jiangsu province by the Shanghai municipal and Jiangsu provincial authorities respectively, there was no guarantee that all the *yinlou*s in the region would take place simultaneously.

In both the cases of salt merchants and *yinlou*s, the key to resolving the obstacle was making the change where it counted. Instead of forcing all salt merchants in one city or province, or *yinlou*s in one county to switch to new units of measurement, the Bureau needed to target the *hubs* of flows of goods or money. In early 1934, the Ministry of Finance finally agreed to use the official system of measurement in the calculation and collection of tax, removing a common

[295] "Jingshi yinlouye zhi xianzhuang" [Current State of Goldsmiths and Silverware Shops], *Anhui caizheng yuekan*, no. 2 (1930): 7.
[296] Austin Dean, *China and the End of Global Silver, 1873-1937* (Ithaca: Cornell University Press, 2020), 118-20.

pretext for sticking to old measures. Thereafter, complaints from local inspectors about merchants selling salt using old measures petered out. In 1933, the Bureau also addressed the problem with *yinlou*s by targeting those businesses in Shanghai. Its directive to the Shanghai Municipal Bureau of Social Affairs specifically noted that owners of *yinlou*s in Jiangsu and Zhejiang provinces were holding back on switching to the new system because they were waiting on Shanghai.[297] Once inspectors in Shanghai were able to force local *yinlou*s to use the new system of measurement, the problem in other administrative regions seemed to dissolve.

LOGGING WOOD: GRAFTING THE MARKET *CHI* ONTO THE *LONGQUAN MUMA DAN*

In the case of the sale of wood, the Bureau identified the critical area of intervention as the *Longquan muma dan*, a historic system used to assess the commercial value of logs. In 1934, the National Bureau of Weights and Measures published a 50-page booklet teaching the sellers of logs how to integrate the new units of length, and rulers and tape measures into this system.[298] This was an additional step which the Bureau did not have to take for sellers of other products who had to switch to new rulers or tape measures. In fact, local inspectors mostly reported that they faced less trouble getting such groups to make the switch to new rulers or tape measures compared to those who used instruments of weight or volume. If almost every other group evidently found it relatively easy to use the meter (*gongchi*), or the market *chi* (*shi chi*), what accounts for the recalcitrance of those who sold logs?

To address this puzzle, it is first necessary to understand how people in China measured logs for sale prior to Nanjing's intervention. In particular, how did rulers or tape measures come

[297] "Zhongyang duliangheng xingzheng xiaoxi: Guanyu Quanguo dulianghengju fangmian" [Updates on central weights and measures administration: Regarding the National Bureau of Weights and Measures], *Duliangheng tongzhi*, no. 7 (Oct 1933): 5.
[298] Shiyebu Quanguo duliangheng ju [Ministry of Industries, National Bureau of Weights and Measures], *Xinding shichi muma zhi yuanli jiqi yingyong* [The Principles and Uses of the New Market *Chi* Muma System] (Nanjing: Guomin shuju, 1934).

into play in the process? What made it so difficult for sellers to use the new sorts of rulers and tape measures mandated by the Nationalist government? By the 1920s, people buying and selling wooden boards in Shanghai were already used to using the unit *fangchi* (most likely the square meter), including those imported from the US and Japan.[299] Logs were different— their irregularity made it difficult to calculate their volume. Plus, their unwieldiness made it challenging to weigh them. Given the size of most logs, such a procedure would have been very clumsy. Instead, the instrument of choice for logs were "soft rulers" (*ruan chi*), or tape measures. Articles on the measurement of logs in China published in the first half of the twentieth century invariably refer to *mie chi* or *miepian chi*, tape measures made of bamboo splints to achieve the flexibility necessary to match the curvature of logs. This common label referred to a variety of instruments. In some places, splints were joined end-to-end, while in others they were affixed in a row.[300] One article explained that there were two kinds of bamboo tape measures used locally, one made with more slender splints than the other. The latter was especially unfavorable to the buyer because the coarse splints only encircled the log loosely. [301]

The *miechi* played a critical role in the *Longquan muma dan*, a system identified since the turn of the twentieth century as the most widely used system for measuring logs in China. In one regional gazette published in 1904, an official tackling the question of how to calculate the *likin* (*lijin*), a tax levied on goods in transit throughout the empire, singled out the *Longquan muma dan* as the best option for calculating the amount owed for logs. The report on the situation in Jiangxi province noted that wood merchants used a variety of practices of measurement but

[299] "Shanghai muye zhi diaocha" [Survey of Shanghai's timber sector], *Xinwenbao*, March 12, 1920, 3.
[300] "Woguo mucai zhi liangfa [Methods for measuring timber in my country]," *Shiye zazhi*, no. 37 (1920): 76-77.
[301] Li, Lu, and Wang, "Shang xinhe muye qingxing" [State of timber sector in upper Xinhe [Hebei province]], 37.

recommended the *Longquan muma dan* specifically because it was most prevalent.[302] In Republican China, people concerned with studying and promoting the domestic and international sale of Chinese timber likewise put the *Longquan muma dan* at the heart of the sector. A nationwide survey carried out by the Bureau in 1933 found that the *Longquan muma dan* was either completely or partially used in the Yangtze River and Pearl River deltas (i.e. most of southern China). In contrast, returns from northern China tended to reflect regional perplexity about a system which had, by some accounts, been in use since the late Ming dynasty (1368-1644).[303]

The *Longquan muma dan* was a set of conventions which assigned values for the amount of wood being traded based on the circumference of logs. It came into play at the point of sale when customers selected the individual logs they wanted to buy at the "wood sheds" (*mupeng*) of sellers. At this point, middlemen dedicated to the task of measuring logs, (*liangmu shou*), measured the circumference of chosen logs with bamboo tape measures.[304] Accounts of *the Longquan muma dan* record different conventions for the positions along the log at which the circumference was taken. In 1933, inspectors in Guangxi province reported that this was done three *chi* from the root of logs while Li, Lu and Wang, record that in Hebei province the prevailing convention was five *chi* from the bottom of the log.[305] [306] Then, based on these measurements, the amount of wood being sold (for each log) would be assigned a customary

[302] "Huiyi muli anzhao longquan ma jia choushou zhangcheng xiang zhe" [Meeting about taxing according to the price under the Longquan ma], *Jiangxi guanbao*, no. 14 (1904).
[303] Shiyebu Quanguo duliangheng ju [Ministry of Industries, National Bureau of Weights and Measures], *Xinding shichi muma zhi yuanli jiqi yingyong* [The Principles and Uses of the New Market *Chi* Muma System], first insert.
[304] Li, Lu, and Wang, "Shang xinhe muye qingxing [State of timber sector in upper Xinhe [Hebei province]]," 46.
[305] These records were produced before 1927. Hence, the *chi* would not have necessarily and probably did not refer to the meter or market *chi*.
[306] Shiyebu Quanguo duliangheng ju [Ministry of Industries, National Bureau of Weights and Measures], *Xinding shichi muma zhi yuanli jiqi yingyong* [The Principles and Uses of the New Market *Chi* Muma System], 9; "Woguo mucai zhi liangfa" [Methods for measuring timber in my country], 76-77.

value using the unit *ma*. There were at least two possible definitions of the *ma*: it could have been either a measure of weight (derived by convention from the circumference), or a measure of market value. But in any case, it described the amount of wood changing hands. Finally, the billable amount for the goods would be derived by multiplying the *ma* assigned to logs with the *guan,* a unit of currency whose value would have been agreed upon between parties to the transaction.[307] Although there were notable regional differences in the use of the *Longquan muma dan*, descriptions of the system written across the first half of the twentieth century by writers speaking to practices in different areas agree that these were the broad outlines of the system.

In the 1910s and 1920s, people who were involved in or concerned about the sale of Chinese wood took the trouble to delineate the *Longquan muma dan*— sometimes in extensive essays— because they identified it as an obstacle for expanding especially the international demand for Chinese wood. This was the general thrust of the 1918 article by Li Deyu, Lu Donglin, and Wang Zuozhen. To them, the system had two major flaws. First, there were many avenues of abuse in the *Longquan muma dan*. Most obviously, the middlemen charged with measuring logs with tape measures could leave their measures hanging slack rather than pulling them taut around the logs. By doing so, they essentially over-charged buyers. Sellers could also swindle buyers by modifying non-standardized tape measures. Second, because the *Longquan muma dan* was so complex and opaque, it worked to obscure rather than make clear the value of Chinese timber to customers, especially those overseas. (By 1940, one critic even claimed that those who sold logs did not really understand the system.[308] It had simply calcified into popular practice.) In contrast, Chinese or foreign customers faced no such issues if they wanted to buy

[307] Li, Lu, and Wang, "Shang xinhe muye qingxing" [State of timber sector in upper Xinhe [Hebei province]], 46.
[308] Zhongquan Ai, "Longquan ma," *Muyejie,* no. 1 *(*1940): 15.

foreign wood. This reasoning led Li, Lu and Wang to the inescapable conclusion that in contrast to foreign practices of quantifying timber the *Longquan muma dan* had become a hindrance for the sale of Chinese timber. It had to go if local producers hoped to regain ground lost to imported wood, and to make inroads in the transnational market. The authors recommended brushing away the *Longquan muma dan* altogether in favor of a blanket use of the cubic *chi* (*lifang chi*), probably the cubic meter, to measure Chinese wood.[309] Unlike the units used under the *Longquan muma dan*, the cubic *chi* would be more internationally legible.

However, it was not just that the *Longquan muma dan* paled in comparison to simpler measures for wood. The *Longquan muma dan*'s twentieth-century users complained that it did not have the kind of precision they wanted or required. It is possible to calculate at least a rough estimate of the volume of a log based on its circumference or radius based on the assumption that it is roughly cylindrical, or even conical in shape. But this was not how the *Longquan muma dan* worked. The *Longquan muma dan* assigned a value for the amount of wood based on circumferences of logs within a 0.5 *fen* (分) range. This means that logs which were slightly thinner or thicker could be assigned the same volume if they fell within the same bracket. Two logs, one with a circumference of 1.05 *chi*, and another slightly thicker one with a circumference of 1.06 *chi* for instance would both be assigned the same value in *ma* even though they might not have balanced the scales. Conversely, two logs with very similar girths could be assigned a different value in *ma* if they happened to fall on either side of a boundary for different brackets. This inexactitude applied for logs of all sizes. Because the *Longquan muma dan* dealt in ranges, a critical review of the system explained that it was not technically a system of measurement at all. Although it was used to generate the values for the amount of wood being sold, these

[309] Li, Lu, and Wang, "Shang xinhe muye qingxing [State of timber sector in upper Xinhe [Hebei province]]," 33-53.

numbers were only an assessment of commercial value rather than an accurate measurement of the dimensions of logs.[310] In other words, the *Longquan muma dan*, operating as it did in categories rather than treating each unique length of the circumference of logs individually, was only a set of trade conventions to facilitate the sale of logs without the fuss of precise calculations on riverbanks and at local markets.

In fact, even the circumference recorded at the point of sale under the *Longquan muma dan* did not necessarily reflect the girth of the log. In some regions, this value also accounted for various types of flaws which might have been present in the wood. When the Bureau asked local inspectors to collect information about the operations of the *Longquan muma dan* in 1933, inspectors in Hunan province reported that sellers of wood took into consideration defects such as holes, rot, curvature, and fire damage.[311] Parties to the sale could agree to mark down the circumferences of logs sold depending on the nature and extent of the damage. Since the recorded circumference of the logs had a direct relationship with volume in the *Longquan muma dan*, agreements to pare down recorded lengths essentially amounted to a discount to compensate for imperfections in the wood. For instance, if buyers spotted cavities near the base of the trunk (the thickest part of logs), they could bargain for between half to one *cun* to be taken off its recorded circumference depending on the size of the holes. The discount would typically be more substantial for a particular type of cavity called the bird's eye (*niaoyan*). The relatively small size of this kind of cavity masked extensive internal rot. It was created when pecking by birds created a deep cavity with a narrow mouth which would later be invaded by moisture and mold. If buyers found the telltale signs of bird's eye cavities (a narrow-mouthed cavity which

[310] Ai, "Longquan ma," 15.
[311] Shiyebu Quanguo duliangheng ju [Ministry of Industries, National Bureau of Weights and Measures], *Xinding shichi muma zhi yuanli jiqi yingyong* [The Principles and Uses of the New Market *Chi* Muma System], 10.

opened into a broader base into the trunk, or knocking and listening for a hollow sound around small cavities), they could negotiate for a substantial reduction of 40 to 50% in the recorded circumference of the log. Similarly, stumpy logs which were shorter than average could have only 70% of their circumference written down on the invoice.[312] By also factoring in such qualitative considerations, the "circumference" written down, like the eventual number of *ma*, was not necessarily a simple reflection of the size of the log either.

The workings of the *Longquan muma dan* shed some light on why sellers of logs lagged behind in the otherwise easy revolution in the measurement of length. Like sellers of other goods, most obviously cloth, units of length were the basis for transactions for sellers of logs. And similarly, there was a direct relationship between the length of cloth or the circumference of logs, and how much customers would expect to pay—as measurements of length (of the circumference of logs or length of textiles) increased, people would expect bigger bills. But as Ding Wenyuan, the officer tasked by the Bureau to study the situation, pointed out, the relationship between the circumference of logs and the *ma* assigned to it was not directly proportional (*bucheng zheng bili*).[313] This meant that the ratio between these two factors was not constant. A person buying cloth at ten dollars a meter could expect to pay ten dollars more or less if they chose to buy or not to buy an additional meter; the change in the bill stayed the same regardless of whether they were buying eleven or a hundred meters of cloth. An extra meter always cost ten dollars more and a meter less always saved ten dollars. With logs, buyers could expect that they *probably* had to pay more for a log whose circumference was, say one *cun*, longer than another. But they could not take the magnitude of this increase for granted. In

[312] Li, Lu, and Wang, "Shang xinhe muye qingxing" [State of timber sector in upper Xinhe [Hebei province]], 44-45.
[313] Shiyebu Quanguo duliangheng ju [Ministry of Industries, National Bureau of Weights and Measures], *Xinding shichi muma zhi yuanli jiqi yingyong* [The Principles and Uses of the New Market *Chi* Muma System], 13.

general, the number of *ma* tended to change by a bigger amount with thicker logs. So, a log with a circumference of 1.25 *chi* might be only a little more expensive than one with a 1.2 *chi* circumference, but there could be a fairly substantial price difference between logs with circumferences of 4 *chi* and 4.05 *chi*. The price difference was likely not the same in these two cases where logs were fatter by 0.05 *chi*. The increase counted for more when the logs were thicker. Thus, while both sellers of cloth and logs were right in saying that units of length were integral to their business, *chi* and *cun* were a little more intricately entangled in the sale of the latter. The government's instructions to redefine them was not a simple proposition for those who used the *Longquan muma dan*; it was not obvious how such a change would affect the conventional relationship between circumference, *ma*, and price. Given this uncertainty, it was not unreasonable for sellers of logs to hold off on disturbing or even destroying the *Longquan muma dan* by using a new set of units of length.

Furthermore, there was some inconvenience attached to inserting the new units of length into the *Longquan muma dan*. One critic of the system noted that despite its multitude of shortcomings, the *Longquan muma dan* had endured for centuries over large swaths of China because it was so easy to memorize and use.[314] If sellers and buyers of wood agreed to simply swap all the old units of length and volume with the new ones announced in Nanjing, it would have broken the numerical elegance of the system. This would have occurred even though (or even because), as the Bureau discovered in its survey, the units of most of the bamboo tape measures used in different regions actually lined up quite closely (though not identically) with

[314] Ai, "Longquan ma," 15.

the new units of the market system.[315] From this perspective, it is understandable that sellers of logs did not give up the convenience of a commonly-used system just to embrace alien units.

Ultimately, the GMD government made only one very specific change to the *Longquan muma dan*. When the Bureau finally turned its attention to the sale of logs, it only inserted the units of length under the market system into it. The booklet it published in 1934 to announce the new approach towards assessing the value of logs was called *The Principles and Uses of the New Market* Chi *System Muma*. Instead of the non-standardized bamboo tape measures of the past, sellers of logs were now directed to use approved tape measures bearing the units of the market system when assessing the size of logs. Then, as before, logs within certain ranges of circumference were matched to a conventional number of *ma*, and thus, the market price of logs would be derived.[316] (Naturally, the new national policy on logs made no mention of the regional practice of allowing people to write down circumferences which were anything other than the value reflected on the tape measure.) Overall, the Bureau changed very little of the *Longquan muma dan*; as the name of the new system indicated, it simply inserted the market *chi* onto practices of measurement and valuation which sellers of logs in southern China were familiar with. By paving the way for sellers of wood to use only legal units of length, and tape measures which had been assayed by certified inspectors, the Bureau addressed prevailing concerns about non-standardization and fraud.

However, and significantly, the new policy sidestepped other complaints about the finicky and imprecise nature of the *Longquan muma dan*. Officers of the Bureau seemed to be concerned only that sellers of logs used the official, national system of measurement. Its 1934

[315] Shiyebu Quanguo duliangheng ju [Ministry of Industries, National Bureau of Weights and Measures], *Xinding shichi muma zhi yuanli jiqi yingyong* [The Principles and Uses of the New Market *Chi* Muma System], 1.
[316] Ibid., 17-33.

booklet addressing the measurement of logs secured this goal. The new market *chi muma* system tidied up the mess of regional instruments and practices, allowing sellers of logs to join everyone else in using the national system of measurement. But the consternation surrounding the *Longquan muma dan* which predated the 1928-29 and 1934 reforms, and which continued after these changes shows that the sector had its own history of measurement— one which briefly intersected with the official push for standardization, but was largely separate from it. The relatively limited intervention of 1934 did not address most of the concerns expressed by those who used the *Longquan muma dan*. In 1940, they were still analyzing its strengths and flaws, and discussing how it could be remade or replaced so that Chinese timber could be appraised more precisely and simply, and sold more widely.[317] These concerns overlapped with official rhetoric about the GMD government's metrological reform about standardization, convenience, and global legitimacy, but the specific ways in which these principles mattered to sellers of wood were left out of the finalized system the Nanjing government imposed on them in 1934.

THE WEIGHT OF POPULAR PRACTICE: SCOOPS OF OILS & ALCOHOLS

With salt, silverware, and logs, the Bureau managed to pinpoint a critical area of intervention. National and local officials also quickly identified the problem with the measurement of small amounts of oils and alcohols for retail sales, but they seemed to be at a loss at how to address it. Wet measures were a slippery problem for reformers from the start of the campaign. Prevailing practices for selling products like soy sauce (*jiangyou*) and Gaoliang wine (*gaoliang jiu*, sorghum wine) in 1920s China were similar to those for other products. Those who bought and sold these products used non-standardized instruments which varied from place to place. But unlike most other products, there were two main ways in which businessmen

[317] Ai, "Longquan ma," 11-15.

measured out oils and alcohols at different points of the supply chain. Wholesalers who dealt in large quantities sold oils and alcohols by weight (*zhongliang*). That is, they weighed out their products using scales, and sold *dan*s or *jin*s to their clients.[318] However, when shopkeepers or stallholders sold small quantities (less than a liter) of soybean oil (*douyou*) or *shaojiu* to individual customers for personal or household consumption, they used instruments of volume (*liangqi*) defined both by the product they were designed to hold and the *weight* of the amount necessary to fill it to the brim.[319] Thus, even though the *jin* and *liang* were units of weight, shopkeepers routinely used instruments of volume called a half-*jin* oil scoop (*banjin you ti*) or a four-*liang* alcohol receptacle (*siliang jiu hu*).

Compared to other products, there was another layer of variation in the sale of oils and alcohols. Whereas those who sold cloth or logs tended to use the same ruler on different kinds of textiles or trees respectively, those who sold oils and alcohols used scoops of varying sizes for different products depending on their relative densities. Density is a measure of the amount of matter in a given volume. Hence, the formula $\rho = m/V$ where ρ is density, and m and V stand for mass and volume respectively. Relative density, sometimes called specific gravity, refers to density in relation to a conventional standard. For liquids, this standard is commonly set as the amount of H_2O molecules in a liter of water, defined as 1kg/*l* (i.e. there is one kilogram of water molecules in one liter of water at 4 degrees Celsius). This measure (1kg/*l*) is unique to pure water; only one liter of water weighs one kilogram. One liter of any other liquid, with its own density relative to water, would weigh either more or less than one kilogram. Thus, one-*jin*

[318] Oils and alcohols were also taxed by weight. After the Ministry of Finance switched to the new system of measurement in early 1934, taxes on oils and alcohols were calculated using units of *weight* in the market system.
[319] Shiyebu Quanguo duliangheng ju [Ministry of Industries, National Bureau of Weights and Measures], *Youjiu yeti liangqi zhizao fa* [Methods for Producing Instruments of Volume for Liquid Oils and Alcohols] (Nanjing: Rensheng yinshudian, 1935), 1.

receptacles for a denser liquid like soy sauce would be smaller than a one-*jin* receptacle for a less dense product like kerosene (*huoyou*). And since there were no industrial standards for kerosene or soy sauce, the relative densities of these products were variable. In terms of instruments of measurement, this meant that the half-*jin* scoop for soy sauce might vary from place to place—and in fact, they did. The cumulative result of these practices was an unusually high degree of variation in the instruments used by retail sellers of oils and alcohols, even by pre-1927 standards.

The official system of measurement formalized between 1928 and 1929 did not cater for instruments of capacity based on weight. Metrological regulations only provided a list of containers defined by the volume they could hold. The enforcement bylaws of the Law of Weights and Measures included a non-exhaustive list of allowable designs for containers. People were allowed to use cylinders with round or square bases, or conical containers with round or square bases (clause 4). The maximum capacity of all these containers were limited to the units laid out in the Law of Weights and Measures; twice or five times of these units; or, tenths, hundredths, and thousandths of these units (clause 8).[320] This last clause in particular curbed the freedom to design containers based on the relative densities of different fluids. It would not have been legal, for instance, to use a scoop with a maximum capacity of 33.125 milliliters (*cuo*) even if this was the amount of vinegar (*cu*) weighing one *liang*. The government supported the manufacture, inspection, sale, and use only of instruments measuring round numbers like 2,000 liters or 220 milliliters. It manufactured standards and models for this list of instruments, and issued instructions on how to assay these instruments. Given these restrictions, sellers of oils and alcohols thus faced a severely constricted menu of possible scoops and receptacles after 1929.

[320] "Dulianghengfa shixing xize [Law of Weights and Measures Enforcement Bylaws]," *Guominzhengfu gongbao* (*fulu*) 5 (1929): 5.

Initially, the government did not seem to have a clear policy on wet measures. When officials converged on the capital to discuss the state of metrological reform in November 1930, the delegation from Zhejiang province asked the Ministry to resolve the ambiguity surrounding the measurement of oils and alcohols. To these provincial officials, it was not clear how they were supposed to be dealing with the widespread use of different sorts of scoops and receptacles, and they urged the government to plug this gap in the national system of measurement. A truly comprehensive system would also spell out how people were supposed to measure liquids.[321] Two individual inspectors also submitted agenda items seeking the same guidance from national authorities at the same November 1930 meeting.[322]

Unfortunately, there seemed to be no good solution to the problem of how the government could impose a single, neat order on the measurement of oils and alcohols. Collectively, the three relevant agenda items submitted in November 1930 threw up three possibilities. The first option asked the government to force even retailers of oils and alcohols to sell their wares by weight using scales. In this case, the offending containers based on weight, would be completely eliminated. Local inspectors would simply need to ascertain that the instruments of weight used by such businesses were compliant with regulations. One of the inspectors who brought up the issue, Xing Dao, noted that this course of action, though attractively neat, was not viable because it was infinitely more convenient for sellers to scoop out these products with pre-fabricated scoops and receptacles rather than fiddle with a weighing scale at the point of sale. In his estimation, it was highly unlikely that the government would be

[321] Shiye bu [Ministry of Industries], *Gongshangbu quanguo duliangheng huiyi huibian* [Compilation of Materials of National Meeting on Weights and Measures], 37.
[322] Ibid., 62-64, 127-28.

able to coax so many individual sellers to give up the longstanding habit of ladling oils and alcohols.[323]

The second plan asked the government to design standardized scoops and receptacles based on the relative densities of different oils and alcohols. Whereas the first option asked sellers of oils and alcohols to change their existing practices, this plan put the onus of standardization on the National Bureau of Weights and Measures. The Bureau had to study and define standard relative densities (like an industrial standard) for each of the kind of oils and alcohols on the market. Xing Dao cautioned that the sheer variety of these products would overwhelm the bureaucratic capacities of the Bureau.[324] The other inspector who chimed in on the topic, Xiao Kelun, suggested sidestepping the variety of oils and alcohols on the market by designing only a single set of containers for all oils and another for all alcohols. Although this dramatically reduced the amount of work which officials would have to do, Xiao conceded that this would not be a perfect solution because such containers, unlike the ones made to measure by sellers of oils and alcohols, would not accurately reflect the relative densities of different fluids.[325]

Ultimately, both Xiao and Xing seemed to recommend the third plan of forcing sellers of oils and alcohols to use the instruments of volume already laid out in metrological regulations. Xiao's comments on the issue in particular specified that officials should ensure that these businessmen did not illegally modify these containers, for example by inserting convex or concave bases to modify their capacities.[326] Compelling sellers of oils and alcohols to use the existing list of instruments which had not been designed with their practices in mind seemed to

[323] Ibid., 63.
[324] Ibid.
[325] Ibid., 127.
[326] Ibid.

be the simplest way for the government to pursue the standardization of wet measures. Attendees at the 1930 meeting did not choose from these nonideal options. The meeting's attendees do not seem to have discussed the issue of wet measures at all.

Unsurprisingly then the problem returned to haunt officials in the 1930s. In 1931-32, a national policy for wet measures emerged, perhaps by default. In response to requests for clarification or guidance from local officials, the Bureau replied that the official system of measurement already provided for the measurement of all things, including liquids like oils and alcohols. Specifically, those dealing in fluids should choose from the menu of instruments of volume in metrological regulations. This was the reply that officials from Zhejiang province received when they asked the National Bureau of Weights and Measures to forward models and specialized inspection instruments to assay instruments used to measure oils and alcohols. Provincial officials explained that they needed these specialized instruments because wet measures were the last sticking point in a province which had otherwise embraced the official system of measurement. The response from Nanjing dated October 1931 insisted that there was no need for models and inspection equipment for a special category of instruments just for oils and alcohols because the existing system of measurement already catered to the needs of those who had to measure liquids. Inspectors in Zhejiang should just use the models, and inspection instruments and instructions which they already possessed for instruments of volume. If they needed more of such equipment to facilitate the production or inspection of liquid measures, they could order these from the national factory run by the Bureau.[327] In 1932, the National Bureau of Weights and Measures doubled down on this policy even as local officials from different parts of China reported difficulties with getting sellers of oils and alcohols to make the switch. In

[327] "Shiyebu zhiling gongzi di ersanbasi hao" [Ministry of Commerce Directive no. 2384], *Shiye gongbao*, no. 40 (1931): 15.

February, in response to the question of whether liquids should be measured by weight or volume from Shanghai, the Bureau responded that these should be measured by volume.[328]

National leaders of metrological reform also firmly rejected local initiatives which deviated from the plan for sellers of oils and alcohols to use containers already sanctioned in the metrological regulations. In 1932, inspectors in Nanjing attempted to reconcile the existing metrological practices of retail sellers of oils and alcohols on the one hand, and the national policy on wet measures on the other. In February, they submitted prototypes for four kinds of alcohol scoops (*jiu ti*) which had been designed based on the weight of different kinds of wines for the Bureau's approval. This proposal struck a balance between the Bureau's pursuit of standardization, and the established customs of the sector. But the Bureau rebuked this effort in April. Besides noting that these prototypes were not compliant with existing regulations, the Bureau's response specifically stated that instruments of volume must be designed based on how much they could hold, and that units of weight like *jin liang* cannot be used to describe or name instruments of volume.[329] By 1932 then, national policy insisted that instruments and units stay in their designated lane: the system tied containers to units of volume, and scales and weights to units of weight. The old practice of scooping out however many *liang* of wine or oil was a category mistake. Inspectors were supposed to root out this practice by forcing sellers of oils and alcohols to use only the limited set of sanctioned containers defined by their volume.

Sometime between 1932 and late 1934, the government changed its tune on wet measures. In September 1934, officials in Jiangsu, Hebei, and Zhejiang provinces received guidance which stated that in situations where it was not possible to convince sellers of oils and

[328] Shiye bu quanguo duliangheng ju [Ministry of Industries, National Bureau of Weights and Measures], *Youjiu yeti liangqi zhizao fa* [Methods for Producing Instruments of Volume for Liquid Oils and Alcohols], 3-4.
[329] Ibid., 4.

alcohols to use legally sanctioned containers, local officials could work towards standardizing containers based on the weight of the most common products in the area. Each of these responses included the qualifiers that this concession was only a temporary (*zanshi*) or relief (*jiuji*) measure— stock phrases which admitted that policy was bowing to unyielding reality.[330] In 1935, the Bureau published a 20-page booklet that expanded on and formalized the new approach towards wet measures. It laid out a menu of three approaches to wet measures. The first option asked inspectors to enforce the metrological system by requiring oils and alcohols to be measured using the instruments of capacity laid out in the law. The second option applied an international practice to China. The Bureau's officials noted that countries like England and the US used instruments like the one-pound glass bottle, an instrument of capacity defined by the weight of what it could carry. In fact, these bottles were crafted based on the weight of water which had the convenient density of 1kg/*l*. This was also common practice in foreign countries which had adopted the metric system. This option asked local officials to design standardized scoops and receptacles for oils and alcohols based on the density of water. The last, and least ideal, option accommodated popular practice by asking local officials to issue guidelines for standardized instruments for doling out oils and alcohols based on the type of product and its weight. To use this option, local officials had to set arbitrary conventions for the relative density of common products like soy sauce, vegetable oil (*caiyou*), or Shaoxing wine (*shaoxingjiu*, yellow wine). To set the relative density of kerosene for instance, local officials were directed to collect and mix local samples of this product. Then, they were supposed to extract one market *jin* and measure this volume, hence setting the capacity of a one-*jin* receptacle (*hu*) for kerosene that

[330] "Shiting lingfa suoshu wuzhong youjiu liangqi qiliang biaozhun biao" [Department of commerce issues five standard instruments of volume for oils and alcohols], *Yunnan shengzhengfu gongbao*, no. 294 (1934): 11-13; "Yeti liangqi zhi jianding fangfa ji jianding feie an" [Regarding inspection methods and fees for instruments of volume for liquids], *Gongye biaozhun yu duliangheng* 1, no. 5 (1934): 143-144.

should be manufactured and used across the province, county, or municipality. By following the same procedure for other commonly sold oils and alcohols, local officials would be able to set the capacities of quarter-*jin*, half-*jin*, and one-*jin* scoops and receptacles for a list of oils and alcohols in their jurisdiction.[331]

National policy was not indifferent to these choices. The booklet clarified that inspectors should first try to get people to use the legal set of containers (i.e. the pre-1934 policy) to measure small amounts of oils and alcohols. If this was not viable, the Bureau now allowed local inspectors to ask people to use containers based on the density of pure water. Only if these two possibilities had been ruled out could local inspectors resort to setting local conventions for the relative densities of common products like soy sauce, and designing local scoops and receptacles based on these conventions.[332] Technically, these ranked options kept the possibility of national standardization on the table. However, this was an unlikely outcome. The past few years had already proved the infeasibility of the Bureau's preferred option, and it could not have been that surprising that no local government went for that option. After 1934, some local authorities opted to use containers based on the density of water, but most local authorities chose to establish local standards for common liquid products. This least-best option led to a great deal of variation in terms of the containers that merchants would be allowed to use across the country. In 1935, local authorities began to submit their own standards for wet measures to the Bureau, and a simple comparison of proposed standards for soy sauce, a common product, suffices to demonstrate the variation under this option. Authorities in the city of Hankou proposed for the one-*jin hu* for soy

[331] Shiye bu quanguo duliangheng ju [Ministry of Industries National Bureau of Weights and Measures], *Youjiu yeti liangqi zhizao fa* [Methods for Producing Instruments of Volume for Liquid Oils and Alcohols], 2-5.
[332] Ibid., 2.

sauce to contain 500 milliliters (*cuo*).[333] Inspectors in Wu county (Jiangsu province) set different standardized one-*jin* containers for three classes of soy sauce with capacities of 400 milliliters, 420 milliliters, and 440 milliliters respectively. (Officials from Wu county also proposed different containers for three different classes of Gaoliang wine, and two classes of *shaojiu*.)[334] For the leaders of metrological reform, this outcome must have been uncomfortably close to the bad old metrological days where one could not rely on the meaning of "one *jin*," even within a single county. The clear preference for this approach towards wet measures among local governments also meant that the Bureau's new policy towards wet measures was not likely to produce national standardization. On paper, the Bureau insisted that accommodating the practice of trading in oils and alcohols by weight was only an "interim relief measure" (*guodu jiuji banfa*), but there was, tellingly, no plan for moving on from this provisional state of affairs.

However, the Bureau did not just cede wet measures to chance or chaos. It pursued the narrower goal of *local* standardization. It was clear that national authorities insisted on this when officials from the city of Beiping sought the Bureau's approval for a set of containers based on the density of water in 1935. On the surface, this was not problematic since the Bureau's new policy on wet measures gave local officials the prerogative to choose this approach. The problem was that municipal authorities had earlier applied for and obtained the Bureau's approval for merchants of oils and alcohols in the city to use the legally-sanctioned list of containers. Since Beiping's officials had already chosen a plan to standardize wet measures, the Bureau rejected its later appeal for containers defined using a different method.[335] The Bureau's official response

[333] "Hankoushi wuzhong youjiu liangqi qiliang biaozhun biao" [Capacities of Instruments of Volume for Five Types of Oils and Alcohols for Hankou Municipality], *Gongye biaozhun yu duliangheng* 1, no. 5 (1934): 142.
[334] "Jiangsu wuxian gezhong youjiu liangqi biaozhun" [Standards for various receptacles for oils and alcohols in Jiangsu Wu county], *Gongye biaozhun yu duliangheng* 1, no. 12 (1935): 95-96.
[335] "Zai tongdi yeti liangqi bude liangshi bingyong an" [Regarding allowing concurrent use of two types of wet measures in one region], *Gongye biaozhun yu duliangheng* 1, no. 11 (1935): 81-82.

clarified that each administrative region, whether this was the province, municipality, or county, had to pick only one of the three options. Local authorities could not mix-and-match between the choices for regulating containers used to sell oils and alcohols within one administrative unit.

Overall, the Bureau did seem to have caved on the matter of scoops and receptacles of oils, sauces, and wines. This outcome was perhaps unsurprising given how fiercely sellers of oils and alcohols resisted Nanjing's metrological reform before 1934. National and local officials faced other challenges to their efforts to enforce official system of measurement, but the one from sellers of oils and alcohols was particularly ferocious and unrelenting. The Bureau received multiple complaints that its initial policy for the retail sale of oils and alcohols by volume was unfeasible. In 1932, two associations of purveyors of soy sauce, one in Minhou county (Fujian province) and one in Huaiyin county (Jiangsu province) appealed to the Bureau to allow them to continue to use containers defined by the weight of their products. Both of these petitions highlighted that the legally sanctioned containers contravened commercial practice, and in fact led to disputes. Even local inspectors agreed that the national policy was misguided. Inspectors in Fujian and Jiangsu, where these petitions originated, took the side of these merchants. They agreed that these businesses should be allowed to use their preferred methods for measuring oils and alcohols.[336] Inspectors in Jiangxi province went even further. They informed Nanjing that they had set (temporary) standards for containers based on weight as a provisional relief measure. More broadly, the Bureau received a barrage of appeals from local officials and inspectors calling for a more "accommodating" (*tongrong*) approach towards wet measures. When the Bureau finally formalized an amended policy towards wet measures in 1935, it

[336] Shiye bu quanguo duliangheng ju [Ministry of Industries, National Bureau of Weights and Measures], *Youjiu yeti liangqi zhizao fa* [Methods for Producing Instruments of Volume for Liquid Oils and Alcohols], 4.

conceded that this U-turn was a response to the extreme difficulty of enforcing its original approach.[337]

OBJECTIVES & OBSTACLES: THIN INTERVENTIONS & LOOSE COMMUNITIES

A review of the work done by agents of the Bureau, especially the foregoing case studies, reveals a lot about the campaign. Most obviously, the points of contention between recalcitrant organizations and groups on the one hand, and representatives of the Bureau on the other clarifies that the Bureau wanted specifically to ensure compliance with the system of measurement which had been codified into law. This meant that official agencies had to use the official system (*biaozhun zhi*), and commercial transactions had to be conducted using the market system (*shiyong zhi*). This was why it was unacceptable for salt merchants to use the same units of measurement as the officers who collected tax from them, or for all the silverware shops to use the same scales used by industry leaders in Shanghai. It was not enough to use standardized weights and measures; the Bureau wanted people to use the system of measurement, and the instruments of measurement which had been assigned to them in the Law of Weights and Measures.

The official insistence that people use the specific units laid out in law explains why the Bureau reformed the *Longquan muma dan* in the specific way it did in 1934. Although the users of the system had other kinds of concerns about the *Longquan muma dan*, specifically about its ability to serve the sector in the twentieth century and on the international marketplace, the Bureau's reformed market *chi muma dan* only targeted the uncoordinated use of varying units of length and tape measures by those who used the *Longquan muma dan*. The sellers' other concerns, specifically about imprecision and the opacity of the measures, were simply irrelevant

[337] Ibid.

to the campaign. In fact, in the longer view of the history of measurement in the commercial sale of lumber in modern China, the GMD government's intervention was a rather insignificant episode. The discussion about the shortcomings of the *Longquan muma dan* and the possibilities of reforming it predated the GMD's metrological campaign, and continued after the Bureau closed the case of log sellers. In 1940, one article in *Muyejie* still identified the *Longquan muma dan* as the most pressing problem for rejuvenating the sector. The author still launched the same criticisms which had been articulated decades before because these were their central concerns.[338] Non-standardized measures were only part of the problem, and not the better part of it.

The irrelevance of Nanjing's push for standardization in the sector-specific histories of measurement also playing out in Republican China is even clearer in the case of Chinese medicine. Between 1930 and 1933, practitioners of Chinese medicine had their own tussle with the National Bureau of Weights and Measures. Complying with the new system largely meant that physicians had to use the new definitions of units of weight like *jin* and *liang* to specify the amounts of different herbal ingredients which patients had to add to herbal remedies, and workers in pharmacies had to dole out these ingredients according to these new units. Physicians of Chinese medicine in and around Nanjing, including several counties in Jiangsu province, and the nearby city of Shanghai, responded to government directives to use new types of steelyards and weights with consternation. In June 1931, members of the Shanghai National Medicine Association (*Shanghaishi guoyi gonghui*) met to discuss their response to the orders from Nanjing.[339] In 1932, the National Medicine Association (*Guoyi gonghui*), an umbrella national

[338] Ai, "Longquan ma," 11-15.
[339] "Guoyijie taolun gaige duliangheng wenti [Practitioners of national medicine discuss switch to new weights and measures]," *Minguo ribao*, 1931, June 20, 2.

organization, submitted an eight-point appeal asking the government to excuse practitioners of Chinese medicine from the new system of measurement. The Ministry of Industries flatly rejected the request, writing that all the arguments presented by the association failed to establish a case for national medicine to be exempted from national metrological regulations. The article reporting this disappointing turn of events in *Modern National Medicine* (*Xiandai guoyi*) highlighted that Jiangsu and Nanjing authorities were now pushing local physicians to switch to the new system of measurement.[340] In Shanghai, physicians received similar directives but allowed two deadlines (1 July 1932, and then 1 October 1932) to use compliant instruments of measurement to lapse.[341]

Writing in 1932, one physician based in Nanjing, Zhang Zhilin, gave voice to some of the concerns which likely underpinned the reluctance to use new units of measurement. Zhang noted that the instructions issued to China's physicians were identical to those issued to every other sector. Practitioners of Chinese medicine were just being asked to do what everyone else was already doing. But, Zhang cautioned, Chinese medicine was not like every other sector. Whereas mistakes in other business might lead to losses, miscalculations in medicine cost human lives. Given this immeasurable cost, it was even more important that measurement was accurate in medicine. In light of this, Zhang explained that physicians' specific concern was that if the switch to the new units of measurement was not coordinated across different administrative areas (villages, counties, cities or provinces), tragic cases of confusion could arise if the physicians and pharmacists issuing and filling prescriptions respectively did not operate with identical

[340] "Wujin xian zhongyi gonghui wei duliangheng shi zhi benhui han," [Wujin county national medicine association correspondence to this association regarding weights and measures], *Xiandai guoyi* 2, no. 6 (1932): 92-93.
[341] "Shanghaishi shehuiju wei shishi duliangheng xunling benhui wen" [Text of directive from Shanghai Municipality Bureau of Social Affairs to implement weights and measures (reform)], *Xiandai guoyi* 2, no. 6 (1932): 82-83.

definitions of units like *jin* and *liang*. Miscalculated doses might lead to outcomes like inefficacy, adverse side-effects, and even death. According to Zhang, physicians were just concerned that all of them should adopt the new system simultaneously.[342]

Zhang's insights seem to have been accurate. The National Bureau of Weights and Measures was finally able to dissolve this stumbling block on the road to national metrological standardization when it ironed out an agreement with representatives for all practitioners of Chinese medicine to switch to the new system of measurement *at the same time*. This included, for instance, allowing sufficient time to the right kind of instruments to be produced and obtained by physicians and pharmacists across the country. To further assuage physicians' anxieties about potential misunderstandings, prescriptions written using the new units had to bear a stamp advertising that fact in the initial transitory period. After this agreement, national medicine seems to have fallen in line with the new system of measurement. By 1934, one physician, Hu Zhe-an, writing in the government-sponsored *Industrial Standards and Weights & Measures* could fit the recent developments in measurement in Chinese medicine into the GMD government's standard narrative about its own metrological reform. Hu claimed that the government's standardization campaign had brought much-needed order to a messy situation in which scales differed between regions and even between different pharmacies.[343]

Hu's account, coinciding exactly with the Nationalist government's self-perception of its reform, completely misses out on the older and on-going concerns about measurement among those who practiced Chinese medicine in Republican China. The National Bureau of Weights

[342] Zhilin Zhang, "Shiyong xin duliangheng yi suding guoyao yongliang biaozhun shuo" [To use the new weights and measures it is necessary to quickly set standard doses for national medicine], *Nanjingshi guoyi gonghui zazhi*, no. 8 (1932): 10.
[343] Zhe-an Hu, "Duliangheng xinzhi yu guoyi zhiliao ji gufang jinyong zhi wojian" [My views on new weights and measures, practice of national medicine, and using ancient prescriptions today], *Gongye biaozhun yu duliangheng* 1, no. 4 (1934): 5-6.

and Measures did not have a monopoly on concern about accurate measurement. It was this same consideration which gave practitioners of Chinese medicine pause when they were directed to swap familiar definitions of the *jin* and *liang* with new ones in their prescriptions and pharmacies. And, in fact, Chinese physicians' and pharmacists' concern about measurement in their field pre-dated the GMD metrological reform. Before and after the fracas in 1931-33, many prominent physicians weighed in on another metrological puzzle which was centuries old.

In Republican China, physicians inherited the old problem of how to read ancient prescriptions (*gufang*) handed down in canonical medical texts. Attention focused on two works, namely the *Treatise on Cold Damage* (*Shanghan zabing lun*, hereafter *Cold Damage*) and the *Essential Prescriptions from the Golden Cabinet* (*Jingui yaolüe*, hereafter *Gold Cabinet*). Both texts were attributed to Zhang Zhongjing, a physician who lived during the Eastern Han dynasty (202 BCE-220 CE), and who is valorized as the "father of prescription" (*lifang zhifu*) in the history of medicine in China. For physicians of Chinese medicine, Zhang's *Cold Damage* and *Golden Cabinet* contain a valuable compendium of prescriptions which are still being studied today. But there was a fly in the ointment: there was no consensus about how units of measurement, mostly of weight but also of volume, were defined in Zhang's prescriptions. Physicians could not know for certain what Zhang meant when he wrote that they should add three *liang* of *guizhi*[344] or eight *liang* of *chaihu*[345] to remedies. Throughout the history of imperial China, various prominent scholar-physicians had tried their hand at reading the units in Zhang's ancient prescriptions, primarily by trying to line up the weights and measures of the Eastern Han with the ones they were familiar with.

[344] Ramulus Cinnamomi, twigs of a tree from the camphor family, native to southern China.
[345] Root of Chinese thorowax.

The specific problem was that the *Cold Damage* and *Golden Cabinet* seemed to offer prescriptions which were *much* too potent. If physicians took Zhang's prescriptions at face value, they realized that the quantity of active, herbal ingredients in the resulting concoctions would be too powerful, to the point of causing harm and death. For this reason, the physicians seeking to update Zhang Jingzhong's prescriptions for their own times typically tried to downsize the units originally printed in the *Cold Damage* and *Golden Cabinet*. In the Song dynasty (960-1276 CE), Lin Yi proposed a simple ratio of 3:1, claiming that physicians should add only one *sheng* or one *liang* where Zhang had written three *sheng* or three *liang* respectively. Zhang Jiebin of the Ming dynasty suggested downsizing the units in the *Cold Damage* and *Golden Cabinet* using another rate. In Qing China, the effort to recover the original definition of Han weights and measures in ancient prescriptions by peeling away centuries of misinterpretation was part of the evidentiary scholarship (*Kaozheng* 考證) movement.[346] In the twentieth century, physicians continued to refer to the rates of conversion proposed by the Qing physician Wang Puzhuang's *A Study of Units of Measurement in Ancient Prescriptions* (*Gufang quanliang kao*) as authoritative.[347]

In Republican China, the effort to read ancient prescriptions took on a new urgency. Some of the medical practitioners who joined the centuries-long quest to redeem the value of Zhang Zhongjing's prescriptions connected it to the very survival of Chinese medicine. Ancient prescriptions, handed down across so many centuries, seemed to hold the key for refuting the claim that Chinese medicine was "abstract" and not evidence-based. Physician Ye Jingqiu made this connection in the preface to his *Analysis of Zhongjing's Canon* (*Zhongjing xueshuo zhi fenxi*) published in 1930. Ye noted that Chinese medicine was facing an unprecedented

[346] Zhe-an Hu, "Duliangheng xinzhi yu guoyi zhiliao ji gufang jinyong zhi wojian" [My views on new weights and measures, practice of national medicine, and using ancient prescriptions today], 5-6.
[347] Baicheng Yang, Yikong Qu, "Du Wang Puzhuang Gufang qualiang kaoshu hou" [After reading Wang Puzhuang's A Study of Units of Measurement in Ancient Prescriptions], *Yixue zazhi*, no. 1 (1921): 74-75.

challenge, one that it might not survive. He argued that the defense of Chinese medicine had to begin with the tradition's canonical texts, and (as authors tend to do) located Zhang Zhongjing's *Cold Damage*, the subject of his book, at its core. His volume took on this ambitious task, reviewing Zhang's prescriptions and presenting them as applicable in the twentieth century.[348] In other words, in response to the challenge that Chinese medicine was not evidence-based, champions of national medicine like Ye argued that the proof was in the prescriptions— if only modern physicians could and would interpret these recipes properly.

Two years later, Ye noted that his study had generated a new wave of interest in the issue of ancient metrology in ancient prescriptions.[349] In reality, there was already an earlier steady drumbeat of interest in the topic among practitioners and champions of Chinese medicine. In the 1920s, periodicals like the *Chinese Medical Journal* (*Zhongyi xuebao*) published articles authored by doctors who claimed to have finally resolved the puzzle of units of measurement in ancient prescriptions. Between 1928 and 1930, the physician Tan Linbo, editor of the *Chinese Medical Journal*, published a staggering, multi-part essay on the topic.[350] In 1931, another physician intervened on the long-running dispute, accepting Wang Puzhuang's rejection of the rates proposed by Lin Yi (Song dynasty) and Zhang Jiebin (Ming dynasty), only to propose his own alternative to Wang's proposed rates of conversion.[351]

By 1935, the matter of new units for Chinese medicine was closed for the National Bureau of Weights and Measures. But for Chinese physicians, the question of how to read ancient prescriptions, the infinitely more important question, went on. There was still no

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[348] Jingqiu Ye, *Zhongjing xueshuo zhi fenxi* [Analysis of Zhongjing's Canon], (Shanghai: Shaonian yiyao she, 1930).
[349] Jingqiu Ye, "Gufangji zhi fenliang" [Weights and measures in ancient prescriptions], *Ziqiang yikan*, no. 20 (1931): 23-25.
[350] See first in series Linbo Tan, "Gujin duliangheng kao" [A study of ancient and modern weights and measures], *Zhongyi xuebao* [Chinese Medical Journal], no. 2 (1928): 2.
[351] Ganqing An, "Gufangyao liang kao (xu)" [On dosage in ancient prescriptions], *Guangzhiguan xingqibao*, guangzi 129 (1931): 5-8.

consensus on how to harvest the value of ancient prescriptions, and people continued to try different keys on this lock. As with the measurement of logs, this community had a set of metrological concerns which were separate from and ignored by the Nationalist government's metrological reform. This is among the thick histories of measurement which drop out of view in histories which echo the GMD government's messaging that the main and most important metrological development in twentieth-century China was the government's push for one specific program of standardization and metrication.

The Bureau did not always or fully achieve its narrow goals. They seemed to meet more success with tight rather than loose metrological communities. A tight metrological community was not necessarily concentrated in a constricted geographical area. But in these communities, even if they spread beyond administrative regions, members closely adhered to standardized units of measurement, instruments, and practices. Sellers of rice tended to belong to such tight metrological communities which were bound together by formal and, often, strict procedures for checking weights and measures. The association of rice sellers in Shanghai, for instance, took its duty of metrological regulation very seriously in the twentieth century. It coordinated the assaying of dry measures for this critical food product twice a year, once in the spring, and again in the fall. The specific dates (set by the lunar calendar) were announced in advance, and all rice merchants were instructed to bring their vessels (*hu*) to the city temple where they would be checked for accuracy. Both the inspectors and those supervising the process were elected.[352] There are many indications that the association carefully policed the accuracy of the containers used to scoop out and sell small amounts of rice to the city's residents. The round of inspection conducted in the fall of 1916 was especially strict and closely watched because it had been

[352] "Mihang dingqi jiaohu" [Rice sector conducts regular verification of hu], *Shibao*, 1916, Sept 6, p. 8.

discovered that there were discrepancies between containers which had been certified in the spring.[353] A year later, the association declared that their members could not lend their verified instruments to other merchants lest they be damaged or modified.[354] It was imperative that rice *hu*s were exactly the same everywhere in the city— it was a matter of fairness which struck at the heart of the people's livelihood. Alternatively, the tight metrological community of silverware shops in the area around Shanghai was an unplanned consequence of that city's outsized role in the sector in that region. There is no evidence that owners of silverware shops in Shanghai actively sought to regulate measurement by their counterparts in the region, but one upshot of their dominance of the sector by the early twentieth century was that there was a Shanghai standard in silverware shops in the region. A similar dynamic meant that salt sellers around the country used and insisted on sticking with imperial-era units in the 1930s since those remained the weights and measures used to collect tax. In tight metrological communities, standards were held in place one way or another.

In contrast, there was more room for discretion to define units of measurement or design instruments of measurement in loose metrological communities. While such communities might share certain practices, units or instruments of measurement were likely to be more varied because there were no formal or informal procedures imposing or incentivizing standardization. Retail sellers of oils and alcohols had their own mercantile associations. These organizations played leading roles in coordinating the initial rejection of metrological reform, but it seems that they did not routinely regulate the capacities of scoops and pots even within a particular county. One report from a local official submitted before 1934 explained that part of the reason for the dizzying variation in the containers used to dole out oils and alcohols was the fact that these

[353] "Jiaohu shenfang liubi" [Verifying the hu to carefully guard against fraud], *Xinwenbao*, 1916, Sept 9.
[354] "Buxu miye jiehu" [Rice merchants not allowed to loan *hu*], *Minguo ribao*, 1917, Oct 17, p. 3.

instruments were not made and sold in specialized stores. Instead, scoops and receptacles were made by the people who used them.[355] The decentralized nature of the production of these containers made this a loose metrological community. Although they all sold oils and alcohols by volume based on weight, there were no formal or effective procedures enforcing standardized capacities for scoops and receptacles.

The Bureau was pushing the official system of measurement to two different types of metrological communities. When officials were dealing with tight metrological communities, they faced initial difficulties, but could resolve these when they identified and targeted the centers which set or controlled the standards these communities. In fact, when the Bureau forced the switch to the new system at the point where it mattered, resistance to the new system in other parts of the associated metrological communities seemed to dissolve. This was the case with both the national tax code and silverware shops in Shanghai. The Bureau was operating on the same principle when it reformed the *Longquan muma dan*, a set of conventions which seemed to lie at the core of those who measured logs. Officials also negotiated the challenges of adopting the new system of measurement for the sale of rice with mercantile associations.[356] The situation was fundamentally different with retail sellers of oils and alcohols. There was no strong center in that loose metrological community. This deprived the Bureau of a similar lever they could pull to set sellers of oils and alcohols on the right track.

[355] "Niqing zizhi quchi youti" [Request to self-make curved rulers and oil scoops], *Zhejiangsheng jianshe yuekan* 5, no. 9 (1932): 36.
[356] "Liangshi weiyuanhui changhuiji" [Record of regular meeting of Liangshi commission], *Xinwenbao*, 1932, Jun 21, p. 11; "Duliangheng zhi tuixing" [Implementation of weights and measures], *Xinwenbao*, 1933, Mar 10; "Mingnian eryuewuri shixing liangshiye gaiyong xinzhi liangqi" [Switch to new instruments of volume to measure cereals next year second month fifth day], *Renbao* (Wuxi), 1934, Oct 16, p. 2.

CONCLUSION: INCH DEEP, NOT QUITE MILE WIDE

In 1934, metrological reform collided with the New Life Movement, another official initiative with far more ambitious objectives. While agents of the Bureau only had to worry about the act of measurement, the New Life Movement had a seemingly infinite scope since it targeted all sorts of attitudes, customs and behavior in Chinese society. The campaign's leaders told Chinese people to go to bed early and wake up early; maintain good posture; ensure the cleanliness of their homes; and, to say "I'm sorry" if they bump into others on the street. By adopting such habits in their everyday lives, the Chinese would be reviving the historic values of propriety, justice, integrity, and honor (*liyi lianchi*), and thus, measuring up to being modern citizens of modern China. After the campaign was launched by Chiang Kaishek in February 1934, local associations to enforce the campaign mushroomed around China in the following months.[357] Given the campaign's rhetoric and its concern with quotidian life, Wu Chengluo probably found it easy to reframe metrological standardization as a facet of the all-encompassing New Life Movement. He explained that the widespread use of instruments which did not distinguish between long and short, big and small, or light and heavy for fraudulent purposes revealed precisely a disregard for the kind of life that the GMD regime was inviting Chinese society to embrace. Conversely, using standardized weights and measures accorded with the orderly, hygienic, simple, and frugal New Life the government was now asking people to embrace. For Wu, to use the new metrological system was to live the New Life: "If one wants to

[357] Fukamachi Hideo, "Prairie Fire or The Gimo's New Clothes? Chiang Kaishek's New Life Movement," *The Chinese Historical Review* 17, no. 1 (Jul 2013): 68-71; Arif Dirlik, "The Ideological Foundations of the New Life Movement: A Study in Counterrevolution," *Journal of Asian Studies* 34, no. 4 (Aug 1975): 948- 49.

know if one is living the New Life, they only have to ask themselves if they are using the new standardized system of measurement."[358]

The foregoing examination of the work done by the Bureau's agents in the 1930s reveals that Wu meant something very specific when he prescribed using the new standardized system of measurement. He meant that people should only use instruments of measurement which had been assayed and certified as accurate by the relevant authorities, and only units of measurement laid out in the Law of Weights and Measures. This goal meant that it was not just groups using a jumble of non-standardized measurements which had to change their metrological practices. Officials also intervened in the practices of communities like salt merchants and silverware shop owners who had their own standardized systems of measurement. They had to be made to use the national system of measurement set out by the Nanjing government. The particular nature of the Bureau's objectives also explains why its agents made a very specific intervention in the case of the measurement of the circumference of logs. Although that metrological community had a bundle of concerns (some of which overlapped with official rhetoric about simplicity and global legibility), the Bureau's modification of the *Longquan muma dan* only addressed one: the non-standardization of units of length and bamboo tape measures. The Bureau's insistence that physicians and pharmacists use just the right definitions of *liang*, *jin*, and *sheng* in prescriptions likewise missed the much more pressing discussion about metrology in ancient prescriptions among practitioners of Chinese medicine which predated and outlived metrological standardization. In practice, the Bureau had a tunnel-vision focus on the very narrow objective of ensuring compliance with the legal system of measurement.

[358] Chengluo Wu, "Lunzhu: Shixing Xinshenghuo yu huayi duliangheng" [Treatise: Enforcing New Life and Standardizing Weights and Measures], *Duliangheng tongzhi*, no. 10 (Jul 1934): 1-3.

This review has also revealed some of the limits of the Bureau's reach in the pursuit of national standardization. I have suggested that loose metrological communities such as those who crafted and used scoops and receptacles to dole out small amounts of oils and alcohols presented an especially intractable challenge to the Bureau. Unlike metrological habits which had been shaped and held in place by tax policy, other formal procedures, or even informal practices, the case of scoops and receptacles for oils and alcohols did not present the government with an obvious target for rectification. There was no regulatory switch the government could flip to get the loose metrological community of sellers of oils and alcohols to change the how they measured and the kinds of instruments they used.

Another area which proved similarly intractable for metrological reformers was the private space of the home. When Wu rebranded metrological reform as part of the New Life Movement in 1934, he also reviewed the current state of the campaign. He noted that compliance was still patchy among certain groups: some bookshops still carried reference books using English units of measurement, and some factories were still labeling their products using English units of measurement. People working in construction code-switched between the legal and non-legal units of measurement: blueprints submitted for official approval used legal units of measurement but workers on construction site reverted to foreign or old units. In each of these cases, Wu briefly and gently urged people to cooperate with authorities to realize standardization. His tone was very different when he addressed the problem of measurement in private homes. Homes still hid many old rulers and old scales— and these old units had a habit of leaking out into the public. When women used old rulers to make pieces of clothing for *chengyi* shops, these became the units used to sell clothing. Women also bought the wares of peddlers; if they insisted on existing measures, peddlers tended to cater to the metrological habits

of their customers. Wu's remarks on this stumbling block for the reform were unusually long. In contrast to his quiet confidence that things were moving in the right direction in other areas, he resorted to pleading with housewives to realize the need to embrace the new system of measurement. Wu's ire extended even to the heads of households who had careers in government, education and industry— all areas in which the new system of measurement was increasingly used— for not doing enough to bring the reform home. He scolded the adage ran "regulate the family and rule the state" (*qijia zhiguo*), and hence, it was inconsistent for men to be working to enforce public order when they had not first done the same at home. In his comments, Wu revealed the basis for his frustration about private measures. It was more difficult to police the private space of the home. Apparently, policemen had rebuffed the Bureau's efforts to get them to inspect homes for illegal instruments of measurement. They did not want to "needlessly" get into disputes with housewives.[359] Without the ability to make women use new rulers or scales, or to confiscate these old instruments, Wu was left with exhortation. In the private space of the home, the Bureau had even fewer options than it had with those who designed and made their own scoops and receptacles for oils and alcohols.

[359] "Wujuzhang tang: Huayi duliangheng jingguo jiejia [sic] yi wancheng huayi jinhou ying hezuo nuli zhidian!" [Dialog with Bureau Head Wu: Metrological Standardization Thus Far and Actions to Achieve Standardization!], *Duliangheng tongzhi*, no. 10 (Jul 1934): 6-10.

CHAPTER 4 SCIENTISTS AND THE SCIENTIFIC SYSTEM OF MEASUREMENT: THE METROLOGICAL DISPUTE OF 1934-35

INTRODUCTION: MAELSTROM OVER MINUTIAE

In February 1935, Yan Jici,[360] a physicist at Academic Sinica, published an essay in which he discussed three mathematical puzzles. They were the sort of riddles which peppered the back pages of popular scientific periodicals published in early twentieth-century China. The first problem was that one *gongli* (millimeter) could be equal to a million *gongli*— an arithmetic paradox. The second puzzle was that the multiplication of two lengths measured in *gongfen* (centimeter) did not necessarily produce a result with the unit of centimeter squared (*pingfang gongfen*, centimeter square). His final problem was that four *gongfen* divided by two *gongfen* could fail to produce the neat answer of two.[361] The key to these riddles was that although the terms *gongli* and *gongfen* were written and pronounced identically in all these cases, they could have been used to refer to units of length, area or weight. When Yan wrote this essay, *gongfen* could have meant centimeter, deciacre, or gram; *gongli* could have meant millimeter, centiacre, or decigram. Yan had designed these puzzles to demonstrate that the varying definitions of units like *gongfen* and *gongli* in metrological regulations were confusing and inconvenient for the work done by scientists and mathematicians. His essay was one of a set published in a special issue of *The Eastern Miscellany* dedicated to a debate about China's metrological system which stretched between October 1934 and September 1935.[362] The dispute had been triggered by a petition from the Chinese Physical Society (*Zhongguo wuli xuehui*) (CPS) proposing three

[360] Yan was a student of the physicist Hu Gangfu who was involved in earlier discussions about metrological reform (see chapter one).
[361] Jici Yan, "Lun gongfen gongfen gongfen" [On Gongfen Gongfen Gongfen], *Dongfang zazhi* 32, no. 3 (February 1935): 79-82.
[362] *Dongfang zazhi* 32, no. 3 (February 1935).

changes to the metrological system which the GMD government had promulgated between 1928 and 1929.[363] In the ensuing months, physicists, chemists, engineers, and physicians weighed in on CPS' proposed amendments, and the National Bureau of Weights and Measures mounted a vehement defense of the system it was charged with enforcing throughout the country.[364] Some of the participants who joined the discussion as it dragged on into 1935 noted the unusually heated tone of the exchanges between these men: the Bureau's official response to the CPS petition called Chinese physicists "unlearned," while one physicist sneered that the official nomenclature for units of measurement was "utterly without meaning."[365] Why did such trifling matters as what to call a centimeter inspire such fierce debate among experts and officials? What were they really arguing about?

This chapter answers these questions about a turbulent episode in the history of metrology in Republican China. Those who participated in this debate saw the definition and nomenclature for units of measurement as highly significant. I explain why each of these groups forcefully defended their preferences about the national system of measurement. I begin by contextualizing Chinese physicists' attention to the metrological system within the broader effort to set basic standards and tools for scientific education and research using the Chinese language. The second part of this chapter summarizes the substantive points made by the two main camps in the metrological dispute of 1934-35. Finally, I discuss what the participants in this debate meant when they invoked the term "scientific," and why different groups clashed over the

[363] Chinese Physical Society, *Zhongguo wuli xuehui wei qingqiu gaiding duliangheng biaozhun danwei mingci yu dingyi shi shang xingzhengyuan ji jiaoyubu shu* [Chinese Physical Society Petition to Administrative Yuan and Ministry of Education Regarding Amending the Definition and Nomenclature of Units of Measurement] (1934).
[364] "Fading duliangheng biaozhunzhi danwei dingyi yu mingcheng queli zhi yuanyou (shiyebu quanguo dulianghengju xiang xingzheng yuan shenchahui baogaoshu)" [Rationale Behind Legal Metrology Definitions and Nomenclature (Report from Bureau of Weights and Measures to Assessment Committee of the Administrative Yuan)], *Gongcheng zhoukan* 4, no. 8-9 (January 1935): 120-139.
[365] "Ibid., 138; Xuezhou Wu, "Guanyu wuguo xianxing duliangheng biaozhunzhi zhi yijian" [Opinion regarding our country's current metrological system], *Dongfang zazhi* 32, no. 3 (February 1935): 90.

project of setting a "scientific" system of measurement for China. Although everyone agreed that China needed to have a single, orderly system of measurement, scientists and officials parted ways over the types of activity which should dictate the design of the national system of measurement. This dispute reveals that China's modernizing reformers were committed above all to scientism, and that scientists and the requirements of scientific research and education were marginal in the government's push to "scientize" China.

MR. SCIENCE GOES TO SCHOOL

Mr. Science was an iconic figure in Republican China. Together with Mr. Democracy, he was born in 1919 in an article by Chen Duxiu in *New Youth* (*Xinqingnian*), the flagship publication of the New Culture Movement. In it, Chen forcefully affirmed a popular conviction among Chinese youths and intellectuals that only science and democracy could dispel the darkness looming over governance (*zhengzhi*), morality (*daode*), scholarship (*xueshu*), and thought (*sixiang*) in China. What tends to be less noted about Chen's article is that it was titled "This publication's response to allegations." Chen, as editor of *New Youth*, was responding to severe criticisms about the ideas printed in the magazine, including the recurring calls for China to embrace science. The latest wave of criticism had been triggered by Qian Xuantong's recent proposal that China should consider abandoning its ideographic script since it seemed to stand in the way of disseminating scientific knowledge. Critics colorfully called this proposal "monstrous," "heterodox heresy," and "godless and lawless rebellion." In response, Chen defended Qian's right to consider this drastic option if China's script hamstrung the future of science in the country. He struck a defiant tone, writing that "Even if protecting these two

misters [Mr. Science and Mr. Democracy] from pressure from the government, or attacks and mockery from society costs us our heads or blood, we will not give up."[366]

Science came under attack again in the science versus metaphysics debate of 1923. In that year, the philosopher Zhang Junmai (Carson Chung) published an article titled "Worldview (*Renshengguan*)" in which he tried to draw a limit around what scientific methods of inquiry could establish. In particular, Zhang asserted that scientific methods could not be used on matters of metaphysics. Based on his selection of examples about the appropriate relationships between the self and others, and the organization of socio-political institutions, Zhang was referring to the subject matter of political philosophy and ethics.[367] Other Chinese intellectuals pushed back against Zhang's article. Most of them took the opposing position that scientific methods of inquiry were supreme, universally applicable to all matters. One of Zhang's most prominent opponents was the geologist Ding Wenjiang.[368] Ding asserted that methods (*fangfa*) for extracting and systematizing truths were the essence of science's unique disciplinary strength. These methods were the be-all and end-all for producing knowledge.[369] While Zhang tried to carve out an epistemic space which was off limits to the methods of science, Ding insisted that the latter was the source of all knowledge.

Science was a major watchword of Republican China. But to be more specific, its champions were grappling with at least two slightly different bundles of concerns. The first set, buried within Chen Duxiu's response to critics of *New Youth*, revolved around the question of how scientific knowledge could be taught and learned in China. One of the most pressing issues

[366] Duxiu Chen, "Ben zhi zuian zhi dabian shu" [This publication's response to allegations], *Xinqingnian* [New Youth] 6, no. 1 (1919): 10-11.
[367] Junmai Zhang, "*Renshengguan*" [Worldview], *Qinghua zhoukan*, no. 272 (1923): 3-10.
[368] See Charlotte Furth, *Ting Wen-chiang: Science and China's New Culture* (Cambridge, MA: Harvard University Press, 1970), 94-135.
[369] Wenjiang Ding, "Xuanxue yu kexue (xe): ping Zhang Junmai de "renshengguan" [Metaphysics and Science (continued): On Zhang Junmai's "Worldview"], *Nuli zhoubao* [The Endeavor] 49 (April 22, 1923): 1.

was that of language: could ideographic characters convey science to Chinese society? If not, how else could Chinese people learn science? The second set of issues centered on the question of what contributors of the New Culture Movement and the 1923 debate meant when they urged China to embrace science. By the end of the debate, it became clear that most of China's leading lights were prescribing scientism rather than science. There was a widespread conviction that it was the methods and values associated with scientific inquiry, rather than the resulting claims about nature, that Chinese intellectuals felt the country needed to embrace. This allowed Ding Wenjiang to hold up, for instance, Hu Shi's critique of the Chinese literary classic *Dream of the Red Chamber* (*Hongloumeng*) as an example of "scientific" work.[370] This project of embracing science then, was something different from simply the dissemination of scientific knowledge. Instead, most of China's leading lights were calling for scientism as panacea for China.

The 1934-35 debate between scientists, engineers, educators, and officials about measurement drew from both of these ongoing conversations about science in China. Most directly, the debate about how to define and what to call units of measurement grew out of a broader effort by scientists and educators to ensure that people could teach and speak of science in Chinese. In the years immediately preceding 1934, members of the Chinese Physical Society were working to confirm a catalog of terms related to their field for the Ministry of Education. The physicists were not alone in this mission; there were already other initiatives to standardize terms in other fields. The foreign missionary John Fryer and the Chinese scholar Xu Shou had already kickstarted the process for chemistry in the late nineteenth century in the Jiangnan Arsenal. Fryer and Xu translated not just the names of chemical elements, but also set the

[370] Ding, "Xuanxue yu kexue (xu): ping Zhang Junmai de "renshengguan" [Metaphysics and Science (continued): On Zhang Junmai's "Worldview"], 1.

principles for naming compounds and describing chemical reactions.[371] Members of the Joint Terminology Committee likewise laid the groundwork for the teaching and practice of foreign biomedicine in China by standardizing terms, most critically for human anatomical parts between 1915 and 1927.[372]

Translation was ponderous work. In China, the difficulty was compounded by the fact that there was often no central agency coordinating different translation projects taking place in the late nineteenth and early twentieth centuries. Thus, different groups sometimes produced different terms for the same thing. Discrepancies touched off new rounds of discussions. During such meetings, scientists painstakingly worked out the details for teaching and doing science in Chinese: should the character for oxygen indicate its phonetic closeness to half of the concept of Yin-Yang, or should it be cleansed of this unsavory association? Was it inconsistent or confusing to include the radical for fire (*huo* 火) in the character designating nitrogen, a non-flammable gas?[373] Although the work was tedious, some of China's leading scientists involved in this work early in the twentieth century emphasized that it was of critical importance. One of them, Li Shuhua, stated unequivocally that without the ability to speak of scientific problems in Chinese, science would have no future in China.[374] For many of the people invested in bringing science to China, there was no getting around this hurdle. If scientists did not cross it, science would remain a foreign thing, accessible only to a minute minority of the population which had the privilege of

[371] James Reardon-Anderson, *The Study of Change: Chemistry in China, 1840-1949* (Cambridge: Cambridge University Press, 1991), 29-52.
[372] Luesink, "Dissecting Modernity."
[373] Guoli bianyiguan [National Institute for Compilation and Translation], *Jiaoyubu huaxue taolunhui zhuankan* [Published Record of Ministry of Education Chemistry Meeting] (Nanjing: National Institute for Compilation and Translation,1932), 84-85.
[374] Wenfan Yu, *Jiaoyubu tianwen shuxue wuli taolunhui zhuankan* [Published Record of Ministry of Education Astronomy, Mathematics, Physics Discussion] (Nanjing: Jiaoyu bu, 1933), 44.

foreign training and training in a foreign language. Somehow, they had to build the linguistic bridge for science to go native in China, one character at a time.

During the Nanjing decade, the Ministry of Education consolidated the progress which had been made on translation, and expanded this effort as part of its push to support scientific education. The Ministry established the National Institute for Compilation and Translation (*Guoli bianyiguan*) (NICT) in 1932, and charged it with establishing basic standards and tools for teaching scientific subjects in China. The scientists and educators who participated in the work of the NICT felt that they were jump-starting the spread of science in China. They (unjustifiably) blamed their predecessors for pursuing only the superficial trappings of science, namely military technology, in places like the Jiangnan Arsenal. They felt that such myopia meant that earlier initiatives to import western science and technology had not laid crucial foundations to support the more fundamental work of basic scientific research in China.[375] Decades later, they sought out to correct this oversight through the NICT.

The official effort to set science on the right path one term at a time gathered steam in 1932. Chen Kezhong, a chemist who led the NICT, started the ball rolling in his own field. In early August that year, the Ministry of Education convened a commission of chemists to discuss standards for the teaching of the subject in China. Despite the criticism of their Qing predecessors for chasing only military technology, national defense loomed large over the meeting about the teaching of basic chemistry. The meeting opened with a report from a chemist, Lin Xuyong, who had witnessed the Japanese invasion of Shanghai in January 1932 (1.28 Incident). Lin recounted how rumors about the Japanese deploying poisonous gas triggered panic

[375] See Benjamin A. Elman, "Toward a History of Modern Science in Republican China," in *China Studies: Science and Technology in Modern China 1880s-1940s*, eds. Jing Tsu and Benjamin A. Elman (Leiden: Brill, 2014), 15-38. Elman argues that this is an unfair portrait of earlier projects of embracing western science and technology.

among Chinese soldiers, and how incomprehension of the mechanics of electrical fences paralyzed Chinese troops even after these barriers had been neutralized. According to Lin, the lack of general scientific knowledge was crippling Chinese soldiers on the battlefield.[376]

Most of the issues discussed by the group were related to the teaching of basic chemistry to Chinese soldiers and society, and bolstering China's ability to mount chemical warfare.[377] One of the two sub-committees formed in this meeting focused on establishing standards for teaching chemistry at the university and pre-university levels, and approving lists of teaching and reference materials for the subjects at these levels. Its mandate included smoothing out discrepancies in translations of terms related to the field. Members of the subcommittee weighed the pros and cons of competing translations for a handful of elements in the periodic table (oxygen, nitrogen, phosphorous, arsenic, carbon), and confirmed the rules for naming organic and inorganic compounds.[378] On the whole, attention devoted to the translation of terms was modest, and the few agenda items were settled smoothly.

In April 1933, the Ministry of Education extended this effort to astronomy, mathematics, and physics. Between 1-6 April, seventy-one experts met in Nanjing to lay the foundations for teaching these three subjects in schools and universities. Following the chemists, they also drafted and refined proposed standards for teaching these subjects, and approved lists of teaching and reference materials.[379] Compared to the chemists, this group paid more attention to the issue of translated and standardized terms. Opening speeches at this meeting identified standardized

[376] Guoli bianyiguan [National Institute for Compilation and Translation], *Jiaoyubu huaxue taolunhui zhuankan* [Published Record of Ministry of Education Chemistry Meeting], 14-17.
[377] Ibid., 50-63.
[378] Ibid., 218-21.
[379] Yu, *Jiaoyubu tianwen shuxue wuli taolunhui zhuankan* [Published Record of Ministry of Education Astronomy, Mathematics, Physics Discussion], 46, 143-145, 155-158.

catalogs of Chinese terms as the foremost task at hand.[380] When the group dispersed into discipline-specific subcommittees, each group also devoted substantial attention to the issue.

Compared to other scientists, physicists were particularly enthusiastic about supporting the teaching of their subject in school. Unlike their counterparts in astronomy and mathematics who attended the April 1933 meeting, physicists took the initiative to propose *additional* efforts to support the teaching of physics in schools. In addition to the work of reviewing standards, materials, and terms, physicists wanted to raise the standard of teaching in science laboratories in schools. They asked the Ministry to allow CPS to draft minimum standards for science laboratories in schools, and urged the ministry to set standards for laboratory teaching in schools.[381] Yan Jici pushed the Ministry to phase out the use of foreign-language textbooks in the next two years.[382] After the meeting, physicists continued to lobby the Ministry to invest in scientific education. They urged the Ministry to allow schools to purchase laboratory equipment at subsidized rates.[383] Physicists at Academia Sinica also prepared and published curricula detailing the kinds of practical experiments which China's students should carry out in schools and universities.[384] Compared to their peers in other fields, physicists were particularly active in championing scientific education in 1930s. The CPS petition to amend China's metrological system emerged as an outgrowth of this work, and reflected physicists' investment in that project.

[380] Ibid., 4, 9-11.
[381] Ibid., 81-82, 95-96.
[382] Ibid., 203.
[383] Institute of Physics, Academia Sinica, correspondence with Ministry of Education, file 5/7144 (1), SHAC.
[384] Institute of Physics, Academia Sinica, Guozhong wuli shiyan shebei shuomingshu [Manual for Physics Laboratory Equipment in Secondary Schools] (1935), file 5/7144 (1), SHAC.

BY SCIENTISTS, FOR SCIENCE

The April 1933 meeting convened by the Ministry of Education did not settle the issue of standardized terms for physics. The physicists who attended this meeting only agreed on the general principles for assessing proposed terms.[385] The Chinese Physical Society was charged with reviewing and confirming the draft catalog of terms before submitting them for the final approval of the ministry. (The national associations of astronomers and mathematicians were asked to do the same for their fields.) At its next annual meeting in August 1933, CPS follow up on this commission by electing a seven-member subcommittee to review and endorse a draft catalog of terms from the Ministry. (Yan Jici was a member of this subcommittee.)[386] After the conclusion of the society's annual meeting on 4 August, this subcommittee worked furiously for more than a month to complete the task. After breaking down the Ministry's list of about 5,000 terms into seven categories, they held nine meetings between 21 August and 2 September discussing the suitability of these proposed Chinese terms for physics. These meetings typically began at nine in the morning, and lasted the whole day; on three occasions, they even stretched to ten at night. The subcommittee completed its review and sent forty-two booklets containing the finalized terms to the Ministry in early September 1933.[387] The culmination of this work was the publication of *Physics Nomenclature* (*Wulixue mingci*) by the Ministry of Education in August 1934.[388]

[385] Yu, *Jiaoyubu tianwen shuxue wuli taolunhui zhuankan* [Published Record of Ministry of Education Astronomy, Mathematics, Physics Discussion], 125-126.
[386] Zhongguo wuli xuehui [Chinese Physical Society], *Zhongguo wulixuehui dierci nianhui baogao* [Report of the Second Annual Meeting of the Chinese Physical Society] (Beiping: Zhongguo wuli xuehui, 1933), 6. These members were Yang Zhao, Wang Shoujing, Zhou Changshou, He Yujie, Qiu Weiyu, Wu Youxun, and Yan Jici.
[387] Ibid., 48-52.
[388] Guoli bianyiguan [National Institute for Compilation and Translation], *Wulixue mingci* [Physics Nomenclature] (Shanghai: National Institute for Compilation and Translation, Commercial Press, 1934).

But even as physicists celebrated the end of a drawn-out journey towards a standardized Chinese catalog of terms for their field, many of them raised concerns that there were still associated problems to be solved. When the CPS subcommittee for nomenclature submitted its final report to the Society in September 1933, it also reported on the progress that the subcommittee was making in reviewing the proposed names for a list of special weights and measures sent by the National Bureau of Weights and Measures. The subcommittee expressed serious reservations with how the Bureau approached naming special units of measurement— a list of which CPS had been asked to review. In particular, they found it problematic that the Bureau adding the prefix "*gong* (公)" to so many units. They noted that the official intention was probably to reflect that such units were "publicly known" (*gongren*) or accepted, including internationally, as basic units. However, the physicists objected to the fact that official naming practices paid so little heed to the nature of units of measurement. For them, the imbalance between the overuse of the prefix *gong* and relative neglect for the meaning of the units resulted in labels which could easily lead to miscommunication.[389]

Given that physicists evidently had a different approach towards nomenclature, it is not surprising that *Physics Nomenclature* diverged from the terms set out in the Law of Weights and Measures (1929) on several points. *Physics Nomenclature* specified that the basic unit for measuring length, the meter, should be called *mi* 米. This was a partial transliteration from the French "metre" and different from the term specified in the Law of Weights and Measures (1929)— *gongchi* 公尺. Likewise, even though the legal Chinese term for gram was *gongfen* 公分, *Physics Nomenclature* gave this as *ke* 克, a shortened transliteration of "gram," instead.[390] In

[389] Zhongguo wuli xuehui [Chinese Physical Society], *Zhongguo wulixuehui dierci nianhui baogao* [Report of the Second Annual Meeting of the Chinese Physical Society], 51.
[390] Ibid., 23, 67, 95.

view of these discrepancies, the National Bureau of Weights and Measures issued a directive for this volume to be withdrawn because of its noncompliance with metrological law in September 1934, almost immediately after it appeared.[391]

By then, the physicists were already aware that their standardized terms for units of measurement were different from those pushed by the Nanjing government. In fact, CPS members had decided that besides nomenclature, there were other problems with China's official system of measurement which the government had to address. At the third annual general meeting of CPS in August 1934, the subcommittee which had assessed the draft catalog of terms in August-September 1933 introduced a motion for the society to petition the government to improve what they saw as a flawed metrological system. The general meeting approved this motion, and endorsed the proposed text of the petition outlining the flaws in China's official system of measurement.[392] The petition was published two months later and kickstarted a vigorous debate about a system of measurement which the Bureau had been enforcing throughout the country.[393]

The fifteen-page petition outlined three problems with China's metrological system. First, the physicists pointed out that the two metrological statutes contained two different definitions of the liter. They proposed eliminating this discrepancy by specifying that the liter was equal to 1.028 cubic decimeters.[394] In 1929, the government had defined the liter as being equal to one

[391] "Zi jiaoyubu: gongzi 10644 hao: qing zhuangchi guoli bianyiguan xun jiang wulixue mingci yishu guanyu dulianghen mingcheng xizhao dulianghengfa fenbie xiuzheng zai yu faxing you" [Directive 10644: Requesting National Translation Agency to Amend Nomenclature for Weights and Measures in Physics Nomenclature], *Shiye gongbao*, no. 97 (1934): 55-56.
[392] *Zhongguo wuli xuehui disanci nianhui baogao* [Report of the Third Annual Meeting of the Chinese Physical Society] (Beiping: Beihua yinshuaju, 1934), 9.
[393] Chinese Physical Society, *Zhongguo wuli xuehui wei qingqiu gaiding dulianghen biaozhun danwei mingci yu dingyi shi shang xingzhengyuan ji jiaoyubu shu* [Chinese Physical Society Petition to Administrative Yuan and Ministry of Education Regarding Amending the Definition and Nomenclature of Units of Measurement].
[394] Ibid., 3-4.

cubic decimeter in the Law of Weights and Measures. The amendment by the physicists would have made the legal definition of the liter more precise, specifically down to the third decimal place. Second, CPS objected to the mislabeling of mass (*zhiliang*) as "weight" (*zhongliang*) in Chinese legislation. The report's writers echoed physics textbooks by explaining that mass denoted the quantity of matter while an object's weight was an indication of the interaction between its mass and the force of gravity. (Hence, a change in gravitational conditions causes a change in an object's weight, but not its mass.) The physicists asked the government to replace all mentions of weight with mass, and to add a clause clarifying that weight was a functional rather than a basic unit. For the physicists, it was inaccurate to mislabel "mass" as "weight," and to state that a liter was one cubic decimeter when it was really 1.083 cubic decimeter.[395]

The appeal to the government reserved special ire for the third problem with China's current system of measurement: nomenclature. The physicists criticized the current list of terms as "inappropriate."[396] According to them, the repeated and varying definitions of terms like *gongfen* illustrated the problems with the names that the government had finalized in 1929. *Gongfen* was centimeter, deciacre, or gram. If *gongfen* was used to convey length (centimeter), it referred to a length which was one-hundredth of the basic unit, the meter. If *gongfen* referred to deciacre, it denoted a unit which was a tenth of the basic unit, the acre. Alternatively, *gongfen* could be a unit of mass which was one-thousandth of the basic unit, the kilogram.[397] Since the two characters comprising the term *gongfen* were written and pronounced identically in all three cases, the physicists argued that there was a clear possibility, even a likelihood, for miscommunication and confusion. Readers and listeners could not be sure just what *gongfen*

[395] Ibid., 4-5.
[396] Ibid., 5.
[397] Ibid., 5-8.

meant without more information. For many physicists, including Yan Jici who titled his contribution to the debate "On *Gongfen Gongfen Gongfen*" (*Lun gongfen gongfen gongfen*), this was a fatal failing of the system of measurement which had been promulgated by the Nanjing government.[398] Moreover, *gongfen* was not the only problematic term. The same deficiency plagued two other terms used to refer to small units (of length, mass, and volume), *gongli* and *gonghao*.

To remedy this, CPS proposed to overhaul the system for naming units of measurement. The physicists recommended that China follow other countries which had adopted the metric system by transliterating the original French terms for basic units, and specifying unique prefixes for indicating larger and smaller units according to the decimal order. They had already taken the lead by applying this principle in translating terms for units of measurement in *Physics Nomenclature*. The volume gave the Chinese terms for the meter and the gram as *mi* and *ke* respectively.[399] To scale these basic units up or down, the physicists proposed a list of prefixes. Whereas a foreigner would add the prefix "deca-" to indicate that the unit was ten times of the original unit, physicists asked people to add *shen* 什— a compound character whose second member is the number ten (*shi* 十) in Chinese. A similar line of thinking produced the prefixes for scaling up even further: *bai* 佰, containing the character for hundred (*bai* 百) was the Chinese translation for hecta-; and, *qian* 仟, containing the character for thousand (*qian* 千), indicated that a unit was a thousand times the basic one.[400] These principles produced terms which were

[398] Yan, "Lun gongfen gongfen gongfen" [On Gongfen Gongfen Gongfen], 79-82.
[399] Guoli bianyiguan [National Institute for Compilation and Translation], *Wulixue mingci* [Physics Nomenclature], 67, 95.
[400] Chinese Physical Society, *Zhongguo wuli xuehui wei qingqiu gaiding duliangheng biaozhun danwei mingci yu dingyi shi shang xingzhengyuan ji jiaoyubu shu* [Chinese Physical Society Petition to Administrative Yuan and Ministry of Education Regarding Amending the Definition and Nomenclature of Units of Measurement], 12-13.

radically different from the ones which the Nanjing government had announced in 1929. For example, the legal system of measurement named the basic unit of weight (mass) as the *gongjin*. This was the official translation of kilogram, a unit equal to one thousand grams. But under the principles proposed by CPS, one would transliterate gram as *ke* 克, and then add the character *qian* 仟 to scale it up by a thousand times. In that case, one would write or say *qianke* for the kilogram, and not *gongjin*.

The physicists were pointing out flaws which were obvious to them in their work. The shifting definitions of the terms *gongfen*, *gongli*, and *gonghao* in the Law of Weights and Measures presented difficulties for the work of physicists, and for the teaching of science. Physicists felt this inconvenience acutely because they worked with composite units involving more than one dimension. For instance, the measurement of volumetric density involves dividing an object's mass by its volume. In this process, the ambiguous term *gongfen* could appear up to four times: twice in the equation and twice more in the composite unit, gram per centimeter. As Yan explained in his essay, Chinese physicists found it messy and unclear to use *gongfen* so many times without any clear indication of which of its definitions were applicable in each instance. There would be no such inconvenience in the alternative proposed by CPS because each unit of measurement would bear a unique label. Thus, the system of names designed by CPS would have made more sense in physics classrooms and laboratories.

The society's list of problems with the current system of measurement was informed by their work as physicists, and their ongoing involvement with confirming the basic terms to be used in scientific education. However, and notably, the physicists did not limit their proposal to these domains. They did not ask just to be allowed to use their preferred terms for their work. They wanted precise definitions, and accurate and clear terms, but not just for themselves. They

felt that the rest of China should also use a system of measurement which possessed these qualities. The petition stated that it was unacceptable for the rest of the country to continue using what they assessed to be a flawed, haphazard system.[401] The members of CPS might have started with the motivation that the metrological system should be improved to support the needs of scientists and scientific education, but they wanted the clear benefits of these improvements to be extended to all other kinds of activities throughout China.

IN DEFENSE OF THE OFFICIAL SYSTEM: GOOD ENOUGH FOR "NORMAL USE"

In January 1935, a committee convened by the National Bureau of Weights and Measures to assess the CPS petition released the government's official response. It was a full-throated defense of China's metrological system, comprising a forceful point-by-point rebuttal of the three issues raised by CPS, thirty-five declarative conclusions, and twelve directives.[402] Ultimately, the report affirmed that the current system of measurement was both legally required and appropriate for all types of measurement taking place within Chinese borders.

The report began by tackling the criticism that the two statutes laying out the metrological system contained inconsistent definitions of the liter. After explaining that this discrepancy arose from different methods for deriving the definition of the liter, the report conceded that the physicists' charge was accurate. Chinese law did include two different definitions of the liter— one of them was the definition of the metric liter, and the other was the Chinese *gongsheng*. However, the Bureau defended the decision to equate the *gongsheng* with the metric liter on the basis that the difference between these two quantities was small. In fact,

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[401] Chinese Physical Society, *Zhongguo wuli xuehui wei qingqiu gaiding duliangheng biaozhun danwei mingci yu dingyi shi shang xingzhengyuan ji jiaoyubu shu* [Chinese Physical Society Petition to Administrative Yuan and Ministry of Education Regarding Amending the Definition and Nomenclature of Units of Measurement], 14-15.
[402] "Fading duliangheng biaozhunzhi danwei dingyi yu mingcheng queli zhi yuanyou (shiyebu quanguo dulianghengju xiang xingzheng yuan shenchahui baogaoshu)" [Rationale Behind Legal Metrology Definitions and Nomenclature (Report from Bureau of Weights and Measures to Assessment Committee of the Administrative Yuan)], 120-139.

the difference was so minuscule that most other countries also glossed over this discrepancy in their metrological regulations. (France was a notable exception.)[403] The current definition of the *gongsheng* in China's laws was thus acceptable, both because its variance from the metric liter was negligible in "normal use," and because it was acceptable international practice to fudge this technical non-equivalence. Next, the report addressed the charge that China's metrological regulations mislabeled mass as weight. The Bureau responded to the Society's clarification on the difference between mass and weight with the rejoinder that these terms had a different significance in everyday use. In effect, other groups in society routinely used the term "weight" when referring to what physicists carefully designated as mass in their work. To most people, mass was an alien "technical term." Since this was the case, the report rejected the Society's proposal to replace every mention of "weight" in Chinese law with "mass" as "extreme."[404]

Finally, mirroring the original petition from CPS, the Bureau's official response launched into an extended defense of the current approach towards nomenclature and the legal list of terms for units of measurement. This lengthy section laid out several other approaches for naming units of measurement, and argued that the one chosen by the Nationalist government was the best one. Other articles published to explain the government's position emphasized that the official policy was the product of painstaking deliberations which had eliminated all other possibilities as inferior. The experts who were involved in this process had assessed that transliteration from western languages or Japanese tended to produce long strings of characters which were meaningless, especially to the vast majority of China's population who were not familiar with these foreign languages. Other systems for creating new characters to denote units of measurement were also unsatisfactory because they produced newfangled characters which were

[403] Ibid.,120-121.
[404] Ibid., 121-123.

difficult to write, learn, or memorize. The option the Nanjing government eventually chose was the best because they used terms like *chi*, *cun*, *jin*, and *liang* which many people in China were already familiar with. In other words, the government's choice of these terms had been guided by the same concerns behind the design of the market system: the government wanted to make sure that people would find the new system of measurement familiar and easy to use. This section also responded to the criticism that the repetition of *gongfen*, *gongli*, and *gonghao* was confusing using an explanation which had become mantra so late in the report: the different definitions of these terms did not hinder communications about units of measurement in "normal use."[405] But, the report claimed, the current list of terms were not merely functional; it was actually based on the original French system for naming units in a decimal order. By criticizing a set of terms which were based on such an orderly foundation, physicists were embarrassingly revealing their shallow understanding of national studies (*guoxue*). The Bureau's report also rejected the (implicit) charge that the government's reform failed to substantively and fully embrace the metric system— a system which both sides affirmed as the metrological system nonpareil in existence. At more than one point, the report writers took the pains to explain that the most appropriate way to learn from the west was to embrace the "spirit" and "function" of their technologies and practices rather than mere trappings.[406] To the Bureau, the campaign it was implementing was a valid and creative transplantation of the metric system.

Defenders of the official system were in the clear minority in 1934 and 1935. Only two groups expressed support for the Nanjing government's metrological system. The first of these was the Chinese Society for Weights and Measures (*Zhongguo dulianghеng xuehui*), a quasi-official organization consisting mainly of inspectors of weights and measures and chaired by Wu

[405] Ibid., 123-136.
[406] Ibid., 137.

Chengluo, the head of the National Bureau of Weights and Measures. Wu's calligraphy adorned the masthead of the Society's newsletter, the *Weights and Measures Companion* (*Duliangheng tongzhi*), and the National Bureau of Weights and Measures funded its publication after July 1933.[407] In 1935, the Chinese Society of Weights and Measures echoed the Bureau's insistence that only China's government had the authority to set the names for units of measurement; it was inappropriate for the CPS to unilaterally commandeer this right when they were drafting Chinese terms for units of measurement in *Physics Nomenclature*.[408] The other organization in favor of retaining the system of measurement already in place was the Society of Chinese Physicians (*Zhonghua yi xuehui*). Its brief response to the Ministry of Education's solicitation for views on the dispute stated that it would be too disruptive to abruptly change a system which had, by then, been widely enforced for so many years.[409]

The limited and lukewarm support for the official system of measurement stood in sharp contrast to the urgent intensity with which opponents of the official system of measurement wrote about the issue. The vast majority of those who joined the debate agreed with the changes proposed by CPS. In particular, there was a chorus of agreement for the physicists' criticism about the current set of official terms for units of measurement. Physicist Zhang Yihui acknowledged that all possibilities for naming units of measurement had their advantages and flaws, but endorsed the CPS proposal as the best one for China.[410] Cai Fangyin, an engineer, also supported the CPS petition, in particular its suggestion to transliterate foreign labels for units of

[407] "Huiwu jiyao" [Summary of society matters], *Duliangheng tongzhi*, no. 6 (Jul 1933): 1.
[408] Zhongguo duliangheng xuehui [Chinese Society for Weights and Measures], "Zhongguo duliangheng xuehui duiyu duliangheng biaozhunzhi fading mingcheng zhi yijian" [Opinion of the Chinese Society for Weights and Measures on Legal Metrological Nomenclature], *Dongfang zazhi* 32, no. 3 (1935): 92-94.
[409] Zhonghua yixuehui [Chinese Medical Association], "Zhonghua yixuehui wei fading duliangheng mingcheng chengfu jiaoyubu wen" [Chinese Medical Association Response to Ministry of Education Regarding Nomenclature for Weights and Measures], *Yixue pinglun*, no. 125 (1935): 49.
[410] Yihui Zhang, "Biaozhunzhi duliangheng mingming pingyi" [Appraisal of Nomenclature of Standard Metrological System], *Dongfang zazhi* 32, no. 3 (February 1935): 82-85.

measurement. Cai took the principle even further, arguing that *Physics Nomenclature* should have transliterated "liter" as *lite* 立特 rather than the familiar *sheng*.[411] Chemist Hui Zhaolun also agreed that the official list of terms was really a "far cry" from the scheme proposed by CPS. He added that the shifting definitions of the *gongfen* was also problematic for chemists. In fact, Hui wrote, it was an open secret among China's scientific community that the official metrological system did not really support scientific research: Chinese scientists had been using *mi* and *ke* for years. Hui could personally attest to the convenience of these terms, and he urged the government to codify the practice of scientists as metrological law.[412]

A COMMON CONSENSUS: A SCIENTIFIC SYSTEM FOR A SCIENTIFIC CHINA

For the most part, participants in this debate stubbornly stuck to their positions.[413] The coalition led by physicists continued to insist that the official system of measurement was riddled with problems which needed to be resolved, and agents of the Bureau kept insisting that it was perfect. Despite this discord, it should be noted that the participants in the 1934-35 dispute shared a common consensus about the kind of system of measurement which China should have. Essays published from both camps regularly reiterated that the country must have a metrological system based on "scientific principle" (*kexue yuanli*, or *kexue yuanze*). By this they meant that each unit of measurement, its definition, and nomenclature, should be part of a well-ordered system. The men who quarreled about measurement in 1934 and 1935 aspired towards an ideal situation where the complete set of units of measurement in China would belong to a coherent conceptual universe. Furthermore, they wanted this universe to be organized according to the

[411] Fangyin Cai, "Cai fangyin xiansheng zhi yijian" [The Opinion of Mr. Cai Fangyin], *Dongfang zazhi* 32, no. 3 (February 1935): 103.
[412] Zhaolun Hui, "Duiyu duliangheng mingci ji daxiao shuming wenti jidian yijian" [Some Points Regarding the Nomenclature of Units of Measurement and Larger and Small Numbers], *Dongfang zazhi* 32, no. 3 (February 1935): 86-89.
[413] You could say that no one wanted to give an inch.

simplest of orders. This cardinal criterion led almost everyone involved in the dispute to laud the metric system. What they so admired about the metric was the fact that it was underwritten by a singular, decimal logic. Within this system, basic units could be scaled up or down through the addition of prefixes which increased or decreased the unit of a factor of ten. Thus, deci-, centi-, and milli- allowed one to scale, for instance, the meter into a unit which was a tenth, a hundredth, or thousandth of the original. And these prefixes modified other units of measurement in the exact same way. In the minds of these men, the metric was a universe of measurement which sprung from and faithfully adhered to this single rule— the rule of ten. This neat, obvious order was the essence of its perfection. One key allowed any user to navigate the whole system. This steadfast, dependable order marked the metric as a system which adhere to "scientific principle."

They also agreed that metrology mattered. The men who dived into this debate felt strongly that China's system of measurement had to be orderly because this would affect not just commerce or science, but the character of Chinese society itself. The prominent physicist Hu Gangfu began his lengthy contribution to the debate by explaining that a well-ordered metrological system would "unconsciously set society's thinking on the right path."[414] [415] The Chinese Society for Weights and Measures agreed that the right kind of metrological system was an important component of the broader project of "scientizing" China.[416] The Bureau's official response to CPS intoned that its primary mission was rectifying Chinese society's longstanding lackadaisical attitude towards measurement.[417] Many of these men were so invested in this topic

[414] Gangfu Hu, "Duiyu wuguo duliangheng zhi shangque" [Discussion of China's Metrology], *Dongfang zazhi* 32, no. 7 (1935, Apr 7): 182.
[415] See chapter one: Hu Gangfu had also participated in earlier discussions about metrological reform.
[416] "Zhongguo duliangheng xuehui fabian zhi yijian" [Opinion of the Chinese Society of Weights and Measures], 92.
[417] "Fading duliangheng biaozhunzhi danwei dingyi yu mingcheng queli zhi yuanyou (shiyebu quanguo dulianghengju xiang xingzheng yuan shenchahui baogaoshu)" [Rationale Behind Legal Metrology Definitions and Nomenclature (Report from Bureau of Weights and Measures to Assessment Committee of the Administrative Yuan)], 120.

because they believed that just the right definitions and labels for units of measurement— the most scientific ones— would act as important subliminal pedagogical tools which would touch the whole of Chinese society. The question of what to call a centimeter meant so much to them because the right answer meant teaching China order, precision, and clarity. The wrong name would inculcate bad habits of mind. This assumption about the connection between the metrological system and national character enhanced the stakes of the dispute in 1934-35.

Another point of agreement among the participants of the debate was that China had to have only one system of measurement. Within the whirlwind of opinions articulated in 1934-35, there were lone voices pointing out an obvious and painless solution. Scientists, as a relatively small group with special requirements for measurement, should be allowed to use their own metrological system, or a version of the official system of measurement for their work.[418] Essentially, this suggestion built upon the official explanation that the legal system of measurement was good enough for "normal use" by asking the government to allow scientists some metrological freedom for their atypical needs. Such a state of metrological plurality would allow the government to continue to implement its preferred system across most of China while scientists could use the units and terms they found most convenient for research. Within China, only a very small group would be aware of this plurality because they had to toggle between these systems. Scientists would have to check one system of measurement at their laboratory doors, but this was a non-issue for the vast majority of the population who never crossed such a threshold.

Yet, for the most part, people who joined the debate either ignored or explicitly rejected this possibility. CPS had not set out to obtain an exemption to use particular units of

[418] Zhaolun Hui, "Duiyu duliangheng mingci ji daxiao shuming wenti jidian yijian" [Some Points Regarding the Nomenclature of Units of Measurement and Larger and Small Numbers], 88.

measurement or terms only in their field. Instead, the physicists felt that it was imperative that these flaws be corrected for a system which the whole country shared. The Bureau's official response to CPS also explicitly ruled out the possibility of allowing physicists to use their own system of measurement. The report stated that Nanjing's system of measurement could meet the needs of everyone from the international magnate to the housewife, and could do so in perpetuity. Scientists were not an exception. The report's list of conclusions pointedly specified that the legal system of measurement should be used in all educational materials and scientific research.[419]

SCIENTISM WITHOUT SCIENTISTS: WHO COUNTS?

Although there was so much consensus about what China's national system of measurement should look like, and even why that mattered, there were clearly disagreements about various aspects of China's metrological system. What was especially contentious in 1934-35 was the issue of nomenclature. Most of the articles published on the matter focused exclusively or primarily on this issue. A handful of them correctly analyzed that the government and the physicists had different approaches towards naming units of measurement. One missive from the National Bureau of Weights and Measures explained that the official set of terms had been finalized based on local habits (*woguo xiguan*). In contrast, the alternatives were being proposed by an "extremely small minority within academia."[420] The physicist Wu Xuezhou put it slightly differently. He claimed that the government had focused on terms which were common

[419] "Fading dulianghengbiaozhunzhi danwei dingyi yu mingcheng queli zhi yuanyou (shiyebu quanguo dulianghengju xiang xingzheng yuan shenchahui baogaoshu)" [Rationale Behind Legal Metrology Definitions and Nomenclature (Report from Bureau of Weights and Measures to Assessment Committee of the Administrative Yuan)], 138.

[420] Shiyebu Quanguo dulianghengju [Ministry of Industries, National Bureau of Weights and Measures], "Dulianghengbiaozhun zhi fading mingcheng zhi jieshi jiqi zai kexue shang zhi yingyong" [Explanation of Legal Nomenclature for the Standard System and Its Use in Science], *Henan shengzhengfu gongbao*, no. 1199 (Dec 1934): 7-12.

(*tongsu*), and hence, familiar to Chinese society. On the other hand, the CPS members pushing to reform metrological nomenclature wanted it to reflect the principles behind the metric system, most critically its decimal order. This was clearly the priority behind its proposed set of prefixes for units of measurement. However, this meant that the resulting terms were alien to most people. Between a familiar set of terms and one which stuck closely to a theoretical principle, Wu picked the latter. Like his peers, he criticized the current labels as "utterly without order" and "meaningless."[421] This tension between familiar, colloquial terms, and ones which had been chosen or formed to reflect theoretical principles was not exclusive to the discussion about what to call units of measurement. When chemists met in Nanjing in August 1932 to hammer out standardized terms, they also split along these lines. The chemists took a vote for instance on whether to translate arsenic as *shen* 砷 or *pi* 砒, the more popularly used term.[422]

But to be more accurate, the 1934-35 dispute over nomenclature erupted over whether the work of scientists had to be factored into the design of the national system of measurement. In 1934, Chinese physicists pointed out that the choices made in 1928 and 1929 made the system awkward for scientific education and research. In particular, the ambiguous definitions of *gongfen*, *gongli*, and *gonghao* made them unwieldy for physicists and other scientists. Their petition demanded that the needs of science be written into the national system of measurement. In response, champions of the official system of measurement explained that the system worked for "normal use." By this they seemed to mean commercial transactions. The men who drew up this reform were concerned primarily with overhauling measurement in commercial transactions. The National Bureau of Weights and Measures was parked under successive ministries related to

[421] Wu, "Guanyu wuguo xianxing duliangheng biaozhunzhi zhi" yijian [Opinion regarding our country's current metrological system], 90.
[422] Guoli bianyiguan [National Institute for Compilation and Translation], *Jiaoyubu huaxue taolunhui zhuankan* [Published Record of Ministry of Education Chemistry Meeting], 85.

coordinating, supporting, and encouraging economic activity in China. Initially, this was the Ministry of Industry and Commerce. In 1932, this Ministry was succeeded by the Ministry of Industries. When the Bureau set out to implement the campaign for standardization in 1929, the returns from provincial and county authorities focused on the instruments of measurement used for the sale of rice, cloth, coal, sugar, oil and other types of goods. For the Bureau's officers, the measurement which took place when such goods changed hands was the "normal" type of measurement they were most concerned about. Accordingly, the system was tailored to the requirements of such activities. In the 1930s, agents of the Bureau focused almost exclusively on the standards and instruments enforced by trade associations and groups. The government's response to CPS unbraided the tight relationship CPS envisioned between a "scientific" metrological system and one which met the needs of scientists. In this clash, government officials felt that it was more important, even imperative, for the national system of measurement to serve the kind of measurement which the vast majority of Chinese society took part in— that which occurred during the buying and selling of goods. From this perspective, scientists were a very niche constituency within the broader group which the system had to cater to. The government was not willing to bend national conventions for the requirements of a relatively small group.

Officials and physicists also clashed on the question of who had the right to design metrological systems. In particular, they had different visions for the role that scientists should play in that process. Members of the Chinese Physical Society believed that defining units of measurement and metrological nomenclature was scientific work. They pointed to the fact that their foreign counterparts took the lead in reforming and enforcing metrological standards in

other countries, and urged the government to embrace this international norm.[423] Chinese physicists claimed that they had unique authority to assess and improve China's system of measurement as scientists. Sa Bendong, a professor of engineering at Tsinghua University, stressed that metrological matters belonged in the purview of experts, specifically those in the fields of physics, chemistry, and metallurgy. He snidely quipped that the current dispute would melt away if a "benighted minority" would simply leave matters up to the experts.[424] This was also the view of the leaders of the NICT which had commissioned *Physics Nomenclature*, the work which had triggered the dispute. In one of the agency's written responses to its parent ministry, the agency clarified that the project of ensuring metrological standardization across the country was different from the work of designing the metrological system. While the former was an administrative duty of an effective government, the latter task fell under the jurisdiction of those with relevant expertise, namely scientists.[425] The writers of this report believed that since metrology was a scientific matter, scientists should take the lead in signing a national system of measurement. Political actors and bureaucrats should take their cues from the scientific community.

Spokespersons for the National Bureau of Weights and Measures assigned scientists a different role in relation to the national system of measurement. They declared that units of measurement were convention— something decreed by political authority. The Chinese *gongsheng* (liter) was equal to as many cubic decimeters as stated in Chinese law, whatever this number happened to be. The unit was made real (in fact, it was made) by the authority of the

[423] *Zhongguo wuli xuehui wei qingqiu gaiding duliangheng biaozhun danwei mingci yu dingyi shi shang xingzhengyuan ji jiaoyubu shu* [Chinese Physical Society Petition to Administrative Yuan and Ministry of Education Regarding Amending the Definition and Nomenclature of Units of Measurement], 14-15.
[424] Bendong Sa, "Zhongguo duliangheng wenti zhi wojian" [My Opinion on the Problem with China's Weights and Measures], *Dongfang zazhi* 32, no. 3 (Feb 1935): 85.
[425] "Guoli bianyiguan zhi yijian" [The Opinion of the National Institute for Compilation and Translation], *Dongfang zazhi* 32, no. 3 (Feb 1935): 95-96.

state. This was why the Bureau's official response to the CPS petition began with the stark statement that the current system of measurement had legal standing in China.[426] Physicists' refusal to comply with the system and their open call for others to also deviate from the official system of measurement constituted metrological rebellion against the authority of the Chinese state. Physicists' decisions about what to call a centimeter, backed by the Ministry of Education no less, were an affront to the rule of law in China. Scientists, like everyone else, had the obligation to comply with the official system of measurement which had been promulgated by the legitimate government of China. They had no special authority to design or re-design the system of measurement. In this vision, scientific expertise was subordinate to political authority in matters of measurement.

The last act of this dispute took the form of a jostling match between the physicists and government officials. The physicists announced their triumph in the court of public opinion, but were elbowed out of the resolution process. In the first two days of March 1935, representatives from the Ministry of Education, the Ministry of Industries, the National Bureau of Weights and Measures, CPS, and Academia Sinica met to iron out the points raised by both sides. Most accounts of this quick meeting record that the meeting's attendees accepted the principles of the CPS petition. That is, everyone who attended the initial meeting accepted the physicists' claim that China's official metrological system needed to be amended. In order to do so, this meeting agreed that the government would gather written opinions on the issue by May in preparation for

[426] "Fading dulianghengbiaozhunzhi danwei dingyi yu mingcheng queli zhi yuanyou (shiyebu quanguo dulianghengju xiang xingzheng yuan shenchahui baogaoshu)" [Rationale Behind Legal Metrology Definitions and Nomenclature (Report from Bureau of Weights and Measures to Assessment Committee of the Administrative Yuan)], 120.

another meeting later in the year.[427] The Ministry of Industries requested such submission from provincial authorities and educational institutes later in March 1935.[428]

Although it seemed like the government was amenable to the points raised by CPS, the physicists who went to Nanjing in March 1935 did not seem to trust what looked like an optimistic development for their petition. After the March meeting, Chinese physicists rushed to take a number of steps to shore up their position vis-à-vis the government. Instead of leaving the surveying to the authorities, CPS initiated its own poll among teachers of physics and mathematics, and engineers. Its survey asked the teachers and engineers to select one response from four options. The first option was a full endorsement of the CPS petition to amend the official system of measurement. The second option allowed respondents to give a qualified endorsement of the principles of the CPS petition and to suggest additional amendments to the official system of measurement. Teachers and engineers could also choose to fully endorse the current legal system of measurement (option three), or slight modifications to the legal system of measurement (option four). CPS received 177 replies which reflected the broad support their proposal had received when it was debated in periodicals. The vast majority of respondents, 130 of the 177 (35 high school teachers and 95 engineers), checked option one, indicating their full support of the CPS proposal. Another forty (35 engineers and 5 high school teachers) endorsed the principles of the CPS petition, but suggested additional amendments to those raised by the

[427] "Shanghai minbao dengzai xingzhengyuan guanyu gaiding duliangheng biaozhun zhi kaihui qingxing" [Shanghai Minbao Reports on Administrative Yuan Meeting to Discuss Metrological System], *Gongcheng zhoukan* 4, no. 8-9 (1935): 119.

[428] "Han quanguo ge bu, hui, sheng zhengfu: gongzi 11863 hao (1935 March 8): guangyu buchong xiuding duliangheng fa hanqing fashu yijian hansong guobu you" [Request for all political authorities to submit opinions regarding amendments to legal metrological system], *Shiye gongbao*, no. 221-222 (1935): 124-125; "Han quanguo ge duli xueyuan, daxue, xueshu tuanti: gongzi 11863 hao (1935 March 8): guanyu buchong xiuding duliangheng fa hanqing fashu yijian hansong guobu you" [Request for all independent educational institutes, universities, academic organizations to submit opinions regarding amendments to legal metrological system], *Shiye gongbao*, no. 221-222 (1935): 125.

petition. In contrast, only four respondents fully supported the current legal system of measurement. (The final three returns rejected both the legal system of measurement and the CPS petition.)[429] In April 1935, CPS published the results of this poll as an indication that China's scientists and educators stood behind its petition as part of an open letter urging all members of Chinese society to pay attention to the issue (*gao guoren shu*).[430]

As it turned out, the physicists were right to be anxious. In July, they learned that the government was convening a second meeting in August to resolve the metrological dispute. This was not surprising since attendees of the March meeting had agreed that there needed to be a second meeting to review feedback from other agencies and organizations. But the physicists were only learning about the August meeting from newspaper reporting and rumor— CPS had not been invited to send attendees to this meeting.[431] In July 1935, the physicists published yet another open letter expressing their disappointment with being left out of the resolution process given that China's metrological system had an intimate relationship to the "development of science in China," still in its "infancy." They claimed that they were duty-bound as scholars to intervene on the issue, and urged authorities to "humbly recognize" the undeniable truth that their proposal would change the country's system of measurement for the better.[432]

Given how the government left the physicists out in the cold, its final directive resolving the dispute could not have been surprising for them. It rejected the proposals submitted by the physicists, and preserved the system of measurement which had been set in place in 1928 and 1929. The scientists were granted the minor concession of concurrently using their proposed

[429] *Zhongguo wuli xuehui disici nianhui baogao* [Report of the Fourth Annual Meeting of the Chinese Physical Society] (1935), 40-41.
[430] Ibid., 41-45.
[431] Ibid., 40-41.
[432] Ibid., 46-47.

terms only for scientific *research*.[433] This meant that the official system of measurement, with its confusion of "weight" and "mass," and its shifting definitions for *gongfen*, *gongli*, and *gonghao*, would continue to be taught in schools. In other words, the physicists failed on the issues which mattered to them the most. Ultimately, the government side-lined the scientists, and stood behind its chosen system of measurement.

CONCLUSION: SCIENTISTS AND THE SCIENTIFIC SYSTEM OF MEASUREMENT

By late 1934, officers of the National Bureau of Weights and Measures and inspectors of weights and measures had faced a string of problems related to metrological reform. Officials began with early anxieties about the finicky task of forging and certifying China's standards, and the tremendous challenge of ensuring there could be enough rulers, weights, and dippers to meet the staggering demand for such instruments across China. As the reform rolled on, officers of the Bureau also had to worry about special classes of instruments like height charts and weighing scales for physical examinations of students in schools across China.[434] In the 1930s, they also faced the new, and perhaps unanticipated, problem of old instruments. Everyone from the head of the National Bureau to third-class inspectors in counties had to worry about the fact that stallholders at markets, roaming peddlers, and housewives were squirreling away their existing rulers, steelyards, and scoops. As outlined in chapter 3, the Bureau also had to field petitions from different organizations asking to be exempted either from the legal system of measurement, or the national timetable for standardization.

The CPS petition and the dispute it triggered presented a fundamentally different challenge to Nanjing's metrological reform. Besides criticizing specific aspects of the legal

[433] Ibid., 42.
[434] "Zhongyang duliangheng xingzheng xiaoxi: Guanyu Quanguo dulianghengju fangmian" [Updates on central weights and measures administration: Regarding the National Bureau of Weights and Measures], *Duliangheng tongzhi*, no. 6 (Jul 1933): 7.

system of measurement as inappropriate or unsuitable for teaching and doing science, the physicists also challenged some of the principles which had guided the design of the legal system of measurement. Most directly, when the physicists attacked the list of names for units of measurement which had been crafted by Nanjing, they seemed to object to *how* the government had approached metrological reform. As the official responses to the CPS petition in 1934-35 confirmed, the architects of the official metrological system had made many decisions to make it more amenable to popular practice. This consideration meant that the government had confirmed the enforcement of both the standard system, and an auxiliary market system. To accommodate units which Chinese people were more familiar with, metrological reformers had halved the kilogram and shrunk the meter. The same thinking was behind the choice of *chi* rather than *mi* for the meter, and *fen* rather than *ke* for the gram. *Chi* and *fen* had greater currency in China than *mi* and *ke*—alien sounds which were unconnected to the units they were supposed to signify. To champions of the official system of measurement, the government had crafted a valid and creative way to transplant the order for the metric system into China. These concessions to Chinese habit disturbed the physicists because they compromised the perfection of the original metric system. They agreed that changes had to be made to bring the system to China, especially to the much larger group of non-scientists in China. But the physicists felt that these changes should be as unobtrusive as possible. As far as possible, these changes should not distort the order of the metric system. For them, the ambiguity of repeated terms was an unacceptable betrayal of the clarity of the international metric system. The whole point was to bring China in line with the metric system, not to bend the latter to Chinese practice. By articulating such a line of criticism, the CPS petition presented a more fundamental challenge to Nanjing's metrological

reform. It poked holes in the government's insistence that it had come up with the right and best plan to reform measurement in China.

In contrast to other earlier cases of non-compliance by other groups, the physicists also challenged the government's authority to design the national system of measurement. Over the course of the dispute, physicists asserted their authority to amend, and in fact to design, China's system of measurement by virtue of their expertise. In 1934-35, Hu Gangfu did this most directly. Hu's contribution to the discussion about China's legal system of measurement did not stop at adjusting the legal system of measurement so that it could support the work of scientists and scientific education. He agreed with other physicists that China could not settle for the (flawed) system of measurement which Nanjing had formalized a few years ago, but he felt that the piecemeal adjustments proposed by CPS could not salvage the situation either. Instead, referring to an earlier proposal by scientists in Aurora University,[435] he conjured up a new Chinese system of measurement to replace the standard and market systems currently being enforced. It was based on ancient Chinese practices of measurement. Hu wrote glowingly of the simplicity and order of these historical practices, and proposed reviving them with minor modifications as a *new* Chinese system of measurement. The updated metrological system was designed to be easily convertible to both metric and English units. Given these improvements and advantages, Hu was sure that it would eventually displace the metric system as the most popular global choice for measurement.[436] In essence, Hu was charting a different metrological future for China and the world. Although the other members of CPS did not go so far, their petition did push back against metrological reform, and against the GMD government's authority over measurement in a similar way that Hu's proposal did. When physicists stumbled upon the

[435] See chapter one, Tales, Tall and Buried.
[436] Hu, "Duiyu wuguo duliangheng zhi shangque" [Discussion of China's Metrology], 184-189.

issue of the definition and names of units of measurement as part of their work to support scientific education in Chinese schools and universities, they found the system promulgated by the Nanjing government deficient. They also saw it as their duty as scientists to rectify a flawed metrological system for the sake of the development of science in China, and Chinese society in general. For these men, there was a world of difference between defining the liter as one cubic decimeters and 1.038 cubic decimeters, and between calling the meter *mi* compared to labeling it *chi*. It was the difference between the perfect order of the metric system and a haphazard system of measurement which would obstruct the dissemination of scientific knowledge in China and distort the push to teach accuracy to Chinese society. They did not just refuse to use the legal system of measurement. They asserted their right to change the legal system of measurement, set out what they believed to be an unassailable case for a list of changes, and asked the government to make the changes accordingly.

Officials of the National Bureau of Weights and Measures defended the Nanjing government on both these counts. They explained the perfection of the official system of measurement, and they jealously guarded the central government's exclusive authority to dictate the national system of measurement. This was the gist of all the government's responses to the CPS petition starting from the January 1935 report from the commission convened to respond to CPS to the final directive which granted only a very limited concession to deviate from the official system of measurement for scientific research.

The CPS petition also seemed to strike a nerve because it appeared to undermine the twinned official claims that the GMD government's reform instituted a "scientific" system of measurement which also laid the groundwork for the development of science in China. These two related claims consistently appeared in public education materials since the beginning of the

reform in 1929. Although these claims did not headline metrological reform, the officials involved in driving metrological standardization felt it was imperative for the government to reject the allegations that the system did not serve science and scientists, and that it might not be "scientific." Officials asserted the state's exclusive authority to design and dictate the national system of measurement— a rebuke of the physicists' claim to that role—but they also insisted that the legal system of measurement was one which adhered to "scientific principle" and could support the needs of scientists. Officials insisted that people should use the legal system of measurement not just because they were legally obliged to do so but also because it was a "scientific," orderly system. The government was not willing to cede this ground to the scientists who found the official system of measurement defective. In this clash with scientists about whether China's official system of measurement was "scientific" or not, officials clarified that while a commitment to scientism was mainstream, the needs of scientists, a very small group of people, were actually marginal. The 1934-35 dispute clarifies that in the matter of metrology, the GMD government was committed to a brand of scientism that was unmoored from and took precedence over the professional needs and perspectives of scientists. The national metrological system could not flow from scientific journals, and science classrooms and laboratories. When push came to shove, the government chose to allow scientists their own metrological bubble in research but rebuffed physicists' proposals to change the national system of measurement.

AFTERWORD

AFTER THE REVOLUTION: THE GMD'S METROLOGICAL REFORM IN THE PRC

In early 1950, China's most prominent scientists found themselves discussing measurement again. The triumph of the Chinese Communist Party over the GMD in 1949 re-opened the question of China's official system of measurement. Seven members of the Chinese Academy of Science (CAS) (*Zhongguo kexueyuan*) met at the behest of the new government to formalize the Academy's position on the system of measurement which should be promulgated in the People's Republic of China (PRC). Among the group were Yan Jici, the physicist who had participated in the 1934-35 dispute, and Qian Sanqiang, a nuclear physicist who would go on to become the father of the atomic bomb in China. Zhu Kezhen, the geologist who had helped to shape the GMD government's metrological reform, opened the meeting by reporting that one among their number, Lu Xueshan, had represented the Academy at an earlier meeting on the matter among economic planners. At that meeting, Lu had highlighted that the Chinese Physical Society had previously submitted a petition that pointed out problems with the GMD's system of measurement. Zhu explained that the present meeting had been called to discuss whether CAS would adopt their predecessors' position on China's metrological system.

Between 1935 and 1950, CPS had apparently broadened their objections to the official system of measurement. When Lu provided context about the CPS position in February 1950, he noted that Chinese physicists had objected to the official nomenclature for units of measurement but added that CPS had also attacked the basic parameters of the GMD's metrological reform. In its 1934 petition, CPS had left the market system alone. Its petition stated that since the market

system was only temporary, it could be tolerated, even if it was flawed.[437] But after 1935, the physicists apparently changed their minds about the market system. They decided that the market system was backfiring, hindering instead of supporting metrication in China. When he summarized CPS' objection to the GMD's metrological system, Lu pointed out that the Nationalists had enforced two systems of measurement in China. He was referring to the fact that the GMD government had asked government agencies to embrace the standard system directly, but had devised a market system to transition everyone else to the metric system. He felt that China should move towards exclusive use of the metric system as soon as possible. In effect, Lu proposed killing the market system. At this point, Qian suggested that perhaps the CAS did not have to issue an opinion on the market system since it was irrelevant for science. Chinese scientists only used the metric system. But Yan Jici rejected this neutrality. He insisted that it was the duty of scientists to intervene in metrology and pushed for the Academy to issue a formal opinion on the fate of the market system since it affected the whole country. Lu took Yan's side, reiterating that the market system sabotaged metrication in China, and suggested that the government should exploit the revolutionary high tide to finally make China fully metric. Ultimately, Yan and Lu got their way. The meeting supported a resolution to recommend the abolition of the market system.[438] On the whole, this group of scientists still believed that they had a right and duty to help shape the national system of measurement, and there was some hope that the new communist government would stand up for standardization in a way that the GMD regime had not.

[437] *Zhongguo wuli xuehui wei qingqiu gaiding duliangheng biaozhun danwei mingci yu dingyi shi shang xingzhengyuan ji jiaoyubu shu* [Chinese Physical Society Petition to Administrative Yuan and Ministry of Education Regarding Amending the Definition and Nomenclature of Units of Measurement], 14.
[438] "Guanyu duliangheng zuotanhui" [Regarding meeting on weights and measures], file 393/2995, SHAC.

Despite these early discussions about the PRC's official system of measurement, a directive from the national government on the matter only came in 1959. By this time, the first Five Year Plan (1953-57) was over and China was in the midst of the Great Leap Forward (1958-62), the next national plan to dramatically increase production. In June 1959, the State Council (*Guowuyuan*) finally announced the government's plans for measurement in the PRC.[439] The State Council adopted all the recommendations in a report on the topic submitted by the Committee of Science and Technology (*Kexue jishu weiyuanhui*) in March 1959.[440] In essence, the PRC government largely preserved the GMD's metrological system. Like the Nationalists before them, the State Council confirmed that the metric system, now called the *gongzhi*, was the basis for measurement in China. Places or activities that were still using other systems or units were supposed to gradually embrace metric units. The communist government was less enthusiastic about the market system, but the directive stated that it "could be retained" with one amendment. Since the decimal order was the main advantage of the metric system, it was unacceptable that the GMD government had defined a market *jin* as consisting of sixteen *liang*. In the PRC, the market *jin* would consist of ten *liang*. The only exception to this redefinition of the *jin* was Chinese medicine: the sixteen-*liang jin* was allowed to survive only on prescriptions for Chinese medicine to avoid miscalculations and the loss of life.

The government's decision to preserve the system of measurement enforced by its republican predecessors, almost lock, stock, and barrel, was based on the committee's report. The committee assessed that it made sense to continue with metrication: it was the most widely-

[439] "Guowuyuan guanyu tongyi woguo jiliang zhidu de mingling" [State Council Directive to Unify System for Measurement], *Zhonghua renmin gonghehuo guowuyuan gongbao* [Gazette of the State Council of the People's Republic of China] 16, no. 180 (Jul 1959): 311-12.
[440] "Kexue jishu weiyuanhui guanyu tongyi woguo jiliang zhidu he jinyibu kaizhan jiliang gongzuo de baogao" [Report of the Committee of Science and Technology Regarding Unifying China's System for Measurement and Expanding Jiliang Work], *Zhonghua renmin gonghehuo guowuyuan gongbao* [Gazette of the State Council of the People's Republic of China] 16, no. 180 (Jul 1959): 312-15.

used system around the world, including in socialist countries like the Soviet Union. Furthermore, though this result was decades late, people around the country had grown accustomed to either the metric system or the market system. The committee noted specifically that enterprises used the metric system, and that the residents of large villages and cities used the market system in their everyday lives.[441] The State Council's 1959 directive merely rubber-stamped metrological reality.

The committee and State Council also addressed the outstanding issue of nomenclature. The committee's report acknowledged that people used varying labels to refer to units of measurement, and submitted a proposed list of standardized Chinese names for units of measurement in the *gongzhi*. Here, at long last, the physicists got their crystal-clear list of names. The meter was officially rebranded *mi*, and the gram was transliterated as *ke* as per the 1934 CPS petition. The proposal also clarified that the units of "weight" were the same as those for "mass," superficially nodding to the CPS quibble about the GMD government's mistake on this point. More importantly, the government also rewired the meanings of *fen*, *li*, and *hao*, finally resolving the physicists' complaints about *gongfen*, *gongli*, and *gonghao*. Across length, weight, and volume, *fen*, *li*, and *hao* indicated a unit which was a tenth, a hundredth, and a thousandth of the basic unit of measurement. So, the *fenmi* 分米 was the decimeter (1/10 of a meter), the *fenke* 分克 was a tenth of a gram, and the *fensheng* 分升 was a deciliter. Under this system, each term only had one definition. On the matter of Chinese nomenclature for metric units, the communist government largely applied the principles proffered by the scientific community. (The lone exception was the retention of *gongjin* as the familiar term for the kilogram.)[442] The scientists

[441] Ibid., 312.
[442] "Tongyi gongzhi jiliang danwei zhongwen mingcheng fangan" [Proposal for Standardized Chinese Terms for Units in the Gongzhi], *Zhonghua renmin gonghehuo guowuyuan gongbao* [Gazette of the State Council of the People's Republic of China] 16, no. 180 (Jul 1959): 316-17.

managed to rename units according to their preferred principles, but only metric ones, not market ones. In the PRC, scientists still achieved very limited success in their attempts to set measurement on the right track for society at large.

If the committee's reports are to be believed, by 1959, the GMD government's vision for measurement in China had largely become a reality. To a very large extent, the communist government was just confirming and continuing with decisions which had been made some decades before. There was definitely a sense that China was over the hump in terms of installing a national system of measurement. The CCP party-state was looking forward, building on standardized weights and measures in a way that the GMD regime dreamed of but never got the chance to enact on the mainland. The State Council's 1959 directive announced the government's decisions about measurement as part of a broader push to develop a national network of agencies to collect statistics (*jiliang*). The plan was for all sorts of enterprises and levels of government to have divisions, or at least officers, who were dedicated to this work. Across the country, officials and agents were supposed to use accurate standards and instruments to collect information to support the push to supercharge production in China. The State Council's directive connected the push to collect statistics with increasing the production of steel and machines, products which headlined the official drive to increase production during the Great Leap Forward. The report from the Committee of Science and Technology went into greater detail, explaining that collecting statistics was essential for increasing efficiency and the quality of products, and for facilitating the division and coordination of labor. In other words, the government would collect statistics to gauge economic performance, and to make economic plans. In 1959, the government could count on the existence of standardized weights and measures as the basis for its new pivot to the collection of economic statistics. More than

anything else, it was the committee's and the State Council's easy assumption that they could use units of measurement as a basic tool in this way which attests to the fact that China's modern metrological revolution was mostly over by 1959.

The CCP government's approach towards measurement throws into sharp focus certain peculiarities which marked pre-1949 metrological reform and administration. Compared to the offhand way in which the PRC government treated units of measurement as conventions they could use in the push to collect statistics about economic production and growth, there was, naturally, a lot more handwringing over units of measurement in Republican China when these conventions were still in the making. When he was on one of his tours to check the state of the reform in Jiangxi province in 1933, Wu Chengluo, the earnest leader of metrological standardization, was invited by the chief of the provincial inspection center to personally inscribe boards and contribute pieces of calligraphy about the reform. Wu acquiesced, producing nine pieces of writing that expounded on the weighty significance of metrological reform. The series included the most direct observation that standardized, accurate instruments of measurement would minimize commercial loss and eliminate the inconvenience of conversion, but Wu also gestured towards the greater economic significance of metrological standardization by writing that the reform was the "sprout" of scientizing every sector and the "first step" towards establishing industrial standards. Wu framed metrological standardization as loftier still: he wrote that national unification was predicated on metrological standardization, and that induction into the new system of measurement was crucial for scientizing Chinese society. In fact, setting China's metrological system was a project to set all things in order, especially the will of the people.[443] The contrast between Wu's rhetoric and the functional way in which the PRC State

[443] "Tezai" [Special print], *Duliangheng tongzhi*, no. 7 (Oct 1933): 12-13.

Council treated units of measurement highlights that the Nanjing decade was a transitional period in which measurement was freighted with immense significance and remade for a modern China in a modern world.

In 1959, the State Council also made an announcement that would have been unthinkable under Wu's tenure at the head of the national office for metrology. After 1949, there were still places in which people were using English, older Chinese or other kinds of systems of measurement. Some people were also used to terms other than the ones then just being backed by the national government for metric units. The State Council noted the persistence of these non-compliance with the official system and nomenclature for measurement, and instructed them to gradually move towards the national conventions. However, in stark contrast to the stance of the GMD National Bureau of Weights and Measures, the State Council left this matter up to the discretion of local authorities. In both of these situations, the State Council asked local authorities to carefully assess local conditions, consider the habits of the people, and work out plans to gradually bring people in line with the metric system and official terms for metric units. There was no timeline for achieving these objectives and no request for local agencies to report on their progress to national authorities. The PRC government also washed its hands off the naming of units for the market system. In effect, people were free to call these units whatever they wanted. This official nonchalance underlines how active and intrusive the Nanjing government's metrological administration had been when it forged China's modern metrological revolution.

Glossary of Chinese Terms

Ah Q zhengzhuan—阿Q正傳
bai—佰
bai—百
baifen miao—百分秒
banjin you ti—半斤油提
baojin—包金
bianli—便利
biaoben qi—標本器
biaozhun—标准
biaozhun chi—標準尺
biaozhun jin—標準斤
biaozhun ju—標準局
biaozhun qi—標准器
biaozhun sheng—標準升
biaozhun zhi—標準制
bu chi—布尺
bucheng zheng bili—不成正比例
cai chi—裁尺
Cai Fangyin—蔡方蔭
Cai Yuanpei—蔡元培
caiyou—菜油
Caizheng bu—財政部
cao hu—漕斛
Cao Shoulin—曹壽麟
chabuduo—差不多
Chabuduo xiansheng—差不多先生
chang deng—長凳
chashu—差數
chazhihaoli, shizhiqianli—差之毫釐，失之千里
Chen Duxiu—陳獨秀
Chen Gongbo—陳公博
Chen Jingyong—陳儆庸
Chen Kezhong—陳可忠
Chen Wanxi—陳萬喜
Cheng Lin—成麟
chengyi dian—成衣店
chi—尺
Chiang Kaishek (Jiang Jieshi)—蔣介石
Chongqing difang fayuan—重慶地方法院

cu—醋
cun—寸
cuo—撮
dan—擔
danyi—單一
daode—道德
Datong xueyuan—大同學院
dayue—大約
difang biaozhun qi—地方標準器
Ding Wenjiang—丁文江
Ding Wenyuan—丁文淵
Dongfang zazhi—東方雜志
douyou—豆油
duliangheng fa—度量衡法
Duliangheng jianding renyuan yangchengsuo—度量衡檢定人員養成所
duliangheng jiandingyuan—度量衡檢定員
duliangheng qi—度量衡器
Duliangheng tongzhi—度量衡同志
Dulianghang tuixing weiyuanhui—度量衡推行委員會
fangchi—方尺
fangfa—方法
fangzao—仿造
fen—分
fendou jingshen—奮鬥精神
fenke—分克
fenmi—分米
fensheng—分升
fu yuanqi—副原器
fuza—複雜
fu zhi—輔制
ganliang—感量
gao guoren shu—告國人書
gaoliang jiu—高糧酒
genju—根據
gongcha—公差
gongchi—公尺
gonghao—公毫
gongjin—公斤
gongli—公釐
gongren—公認
Gongshang bu—工商部

gongshi—公式
gongwenshu—公文書
gongye biaozhun—工業標準
Gongye biaozhun weiyuanhui—工業標準委員會
Gongye biaozhun yu dulianghen—工業標準與度量衡
gongzhi—公制
Gu Chunting—古春庭
Gu Lang—顧琅
guan—貫
gufang—古方
Gufang quanliang kao—古方權量攷
guocui—國粹
guodu—過渡
guodu jiuji banfa—過渡救濟辦法
Guoli bianyiguan—國立編譯館
Guomindang—国民党
Guowuyuan—國務院
guoxue—國學
guoyi—國醫
Guoyi gonghui—國醫公會
hanhu xing—含糊性
hao—毫
haowu chayi—毫無差異
hege—合格
helihua—合理化
Hongloumeng—紅樓夢
hu—斛
hu—壺
Hu Dunfu—胡敦復
Hu Gangfu—胡剛復
Hu Mingfu—胡明復
Hu Shi—胡適
Hu Yuanbo—胡淵博
Hu Zhe-an—胡蟄庵
hua miao—華秒
huangzhong—黃鐘
huayi dulianghen—劃一度量衡
Hui Zhaolun—會昭掄
huoyou—火油
hushi sanjie—胡氏三杰
jiandan—簡單

jianding—檢定
jianding fensuo—檢定分所
jianding sheng—檢定生
jianding suo—檢定所
jianding yong qi—檢定用器
jianding yuan—檢定員
jiangyou—醬油
Jianshe weiyuanhui—建設委員會
jiben—基本
jichu—基礎
jin—斤
jin chi—鯨尺
Jingui yaolüe—金櫃要略
Jingji bu—經濟部
jingji jianshe—經濟建設
jinliang—斤兩
jingque—精確
jingque jiliang—精確計量
jingxi jianding—精細檢定
jiu ti—酒提
jiuji—救濟
jiuqi—舊器
Kaozheng—考證
ke—克
ke—刻
ke zunding—恪遵定
Kexue—科學
kexue guanli—科學管理
Kexue jishu weiyuanhui—科學技術委員會
kexue yuanli—科學原理
kexue yuanze—科學原則
kexuehua—科學化
Kong Xiangxi—孔祥熙
kuping jin—庫平斤
li—里
li—厘
Li Deyu—李德輿
Li Shuhua—李書華
liang—兩
liangmu shou—量木手
liangqi—量器

liangyuan chi—量圓尺
lifang zhifu—立方之父
lifangchi—立方尺
lijin—釐金
Lin Xuyong—林續庸
Lin Yi—林億
lite—立特
Liu Bingrong—劉炳榮
Liu Jinyu—劉晉鈺
Liu Yinfu—劉蔭茀
liyi lianchi—禮義廉恥
Longquan muma dan—龍泉木碼單
Lou Tongsun—樓桐蓀
Lu Donglin—盧東林
Lu Xueshan—陸學善
luan—亂
luban chi—魯班尺
Lu Xun—魯迅
Lun gongfen gongfen gongfen—論公分公分公分
Lunyu—論語
Qian Sanqiang—錢三强
Qian Xuantong—錢玄同
qijia zhiguo—齊家治國
qimin—器皿
Quandu zhizaosuo—權度製造所
Quanguo duliangheng ju—全國度量衡局
Quanguo shanghui lianhehui—全國商會聯合會
ma—碼
Ma Xiangbo—馬相伯
mi—米
miao—秒
micha—秘查
miechi—篾尺
miepian chi—篾片尺
minxi—民習
minxin—民信
minyong duliangheng biaoben qi—民用度量衡標本器
minyong duliangheng qi—民用度量衡器
mitu chi—米突尺
mu—畝
mu chi—木尺

mupeng—木棚
na baiwu yu guidaoyi—納百物於軌道一
nai tonglu duliangheng suoyi qiyuanjin liminxin ye—乃同律度量衡所以齊遠近立民信也
niaoyan—鳥眼
Niu Yongjian—鈕永建
pingfang gongfen—平方公分
qian—仟
qian—千
qianke—仟克
Renshengguan—人生觀
renzao—人造
ruan chi—軟尺
Ruan Zhiming—阮志明
Sa Bendong—薩本棟
sandai—三代
sanyuan chi—三元尺
Shan Gong—山公
Shanghaishi guoyi gonghui—上海市國醫公會
Shanghan zabing lun—傷寒雜病論
Shanxi sheng—山西省
Shanxi sheng (*Shaanxi sheng*)—陝西省
shaojiu—紹酒
shaoxingjiu—紹興酒
shen—什
sheng duliangheng jiangding suo—省度量衡檢定所
sheng jianding suo—省檢定所
shi—時
shi—石
shi—十
shi chi—市尺
shi jin—市斤
shi sheng—市升
shicha—實差
shiji de qingxing—實際的情形
shijin—十進
shijin zhi—十進制
Shiye bu—實業部
shiyong zhi—市用制
Shou E—瘦鵝
shoushi—首飾
Sifa xingzheng bu—司法行政部

siliang jiu hu—四兩酒壺
sixiang—思想
Sun Wenyu—孫文郁
Sun Yatsen (Sun Zhongshan)—孫中山
taicheng—臺秤
Tan Linbo—譚林伯
tebieshi jianding suo—特別市檢定所
tianping—天平
tianzao—天造
tiao deng—條凳
tizhi danwei—體質單位
tongbing—通病
tongji—統計
tongji shiye—統計事業
tongrong—通融
tongsu—通俗
Tongwen Guan—同文館
tongxing—通行
tongyi—統一
Wang Puzhuang—王樸莊
Wang Shijie—王世杰
Wang Zuozhen—王作榛
wanguo gongzhi—萬國公制
wei—僞
wei—圍
weifa—違法
Weizhuang—未庄
woguo xiguan—我國習慣
Wu Chengluo—吳承洛
Wu Xuezhou—吳學周
wudi—五帝
Wulixue mingci—物理學名詞
wuxin—誤信
wuxingzhong—無形中
wuzui—無罪
xiandai guoyi—現代國醫
Xiao Kelun—蕭克倫
Xie Xinghe—謝興河
xin—新
xin chi—新尺
xin fen—新分

xin jin—新斤
xin sheng—新升
Xing Dao—刑導
Xingzheng yuan—行政院
Xinqingnian—新青年
Xu Shanxiang—徐善祥
Xu Shou—徐寿
Xue Dubi—薛篤弼
xueli—學理
xueshu—學術
xunzheng—訓政
Yan Jici—嚴濟慈
yangfeng yinwei—陽奉陰違
yanshui—鹽稅
Ye Jingqiu—業勁秋
Ye Zaiyang—葉在揚
yidi jieran lüwu xuanzhi—異地皆然略無軒輊
yiersan zhi—一. 三. 三制
Yin-Yang—阴阳
ying chi—英尺
yingzao—營造
yingzao chi—營造尺
yinlou—銀樓
Yuan Shikai—袁世凱
yuanqi—原器
Yuanren zhi—原人制
yuanze—原則
zanshi—暫時
Zhang Deyi—張德彝
Zhang Jiebin—張介賓
Zhang Junmai—张君劢
Zhao Yifeng—趙一峰
Zhang Yihui—張貽惠
Zhang Zeyao—張澤堯
Zhang Zhilin—張植林
Zhang Zhongjing—張仲景
Zhendan daxue—震旦大學
zheng chi—正尺
Zheng Guobin—鄭國斌
zheng liang—正兩
zhengzhi—政治

zhengzhi gongping—正直公平
zhidan—質單
zhiliang—質量
zhonghua danwei zhi—中華單位制
Zhonghua minguo quandu biaozhun fangan—中華民國權度標準方案
Zhonghua yi xuehui—中華醫學會
Zhongguo duliangheng xuehui—中國度量衡學會
Zhongguo kexue she—中國科學社
Zhongguo kexueyuan—中國科學院
Zhongguo wuli xuehui—中國物理學會
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Zhu Wenzhong—朱文中
zhunjiao—准較
Zongli Yamen—總理衙門
zushi, zubing, minxin zhiyi—足食，足兵，民信之矣
zuzhi—祖制

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Nonggongshang bao 農工商報
Nuli zhoubao 努力周報 [The Endeavor]
Qingdao shehui 青島社會
Qinghua zhoukan 清華周刊
Shangwu guanbao 商務官報
Shehui yuekan 社會月刊
Shiye gongbao 實業公報
Shiye zazhi 實業雜志
Shiyebao 實業報
Sichuan guanbao 四川官報

The China Recorder and Missionary Journal
Xiandai guoyi 現代國醫
Xinghua 興華
Xinqingnian 新青年 [New Youth]
Xinhankoushi shizheng gongbao 新漢口市市政公報
Xinguangxi xunbao 新廣西旬報
Yixue pinglun 醫學評論
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Yunnan shengzhengfu gongbao 雲南省政府公報
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Appendix A

Law of Weights and Measures (*Duliangheng fa*), promulgated Feb 1929

Name	Definition	Notes	Name	Definition	Notes
STANDARD SYSTEM, LENGTH			**MARKET SYSTEM, LENGTH**		
No counterpart in standard system			毫 *hao*	1/100,000 of market *chi* 0.0001 chi	
公釐 *gongli*	1/1,000 of 1 meter (0.001m)		釐 *li*	1/1,000 of market *chi* 0.001 *chi* 10毫	
公分 *gongfen*	1/100 of 1 meter (0.01m) 10公釐		分 *fen*	1/100 of market *chi* 0.01 *chi* 10釐	
公寸 *gongcun*	1/10 of 1 meter (0.1m) 10公分		寸 *cun*	1/10 of market *chi* 0.1 *chi* 10分	
公尺 *gongchi*	Basic unit (單位) 10公寸		尺 *chi*	Basic unit 10寸	
公丈 *gongzhang*	10 meters 10公尺		丈 *zhang*	10 market *chi* 10尺	
公引 *gongyin*	100 meters 10公丈		引 *yin*	100 market *chi* 100尺	
公里 *gongli*	1,000 meters 10公引		里 *li*	1,500 market *chi* 1,500尺	*exception
STANDARD SYSTEM, AREA			**MARKET SYSTEM, AREA**		
No counterpart in standard system			毫 *hao*	1/1,000 of market *mu* 0.001 *mu*	
公釐 *gongli*	1/100 of 1 are (公畝)	X100 rather than X10	釐 *li*	1/100 of market *mu* 0.01 *mu*	
No counterpart in standard system			分 *fen*	1/10 of market *mu* 0.1 *mu*	
公畝 *gongmu*	Basic unit 100 square meters (*pingfang gongchi*)		畝 *mu*	Basic unit 6,000 square market *chi*	*exception
公頃 *gongqing*	100 are (*gongmu*)		頃 *qing*	100 market *mu* 100 *mu*	
STANDARD SYSTEM, VOLUME			**MARKET SYSTEM, VOLUME**		
公撮 *gongcuo*	1/1000 of 1 liter 0.001l		撮 *cuo*	1/1,000 of market *sheng*/ liter 0.001 *sheng*	
公勺 *gongshao*	1/100 of 1 liter 0.01l 10公撮		勺 shao	1/100 of market *sheng*/ liter 0.01 *sheng* 10撮	

Name	Definition	Notes	Name	Definition	Notes
公合 *gonghe*	1/10 of 1 liter 0.1l 10 公勺		合 he	1/10 of market *sheng*/ liter 0.1 *sheng* 10勺	
公升 gongsheng	Basic unit 1,000 cubic gongcun (decimeter)		升 *sheng*	Basic unit 10合	
公斗 gongdou	10 liters 10公升		斗 *dou*	10 market *sheng*/ liter 10 *sheng*	
公石 gongshi	100 liters 10公斗		石 *shi*	100 market *sheng*/ liter 100 *sheng*	
公秉 gongbing	1,000 liters 10公石		No counterpart in market system		
STANDARD SYSTEM, WEIGHT			**MARKET SYSTEM, WEIGHT**		
公絲 *gongsi*	1/1,000,000 of 1 kilogram 0.000001kg		絲 *si*	1/1,600,000 of market *jin* 0.000000625 *jin*	
公毫 *gonghao*	1/100,000 of 1 kilogram 0.00001kg 10公絲		毫 *hao*	1/160,000 of market *jin* 0.00000625 *jin* 10絲	
公釐 *gongli*	1/10,000 of 1 kilogram 0.0001kg 10公毫		釐 *li*	1/ 16,000 of market *jin* 0.0000625 *jin* 10毫	
公分 *gongfen*	1/1,000 of 1 kilogram 0.001kg 10公釐		分 *fen*	1/1,600 of market *jin* 0.000625 *jin* 10釐	
公錢 *gongqian*	1/100 of 1 kilogram 0.01kg 10公分		錢 *qian*	1/160 of market *jin* 0.00625 *jin* 10分	
公兩 *gongliang*	1/10 of 1 kilogram 0.1kg 10公錢		兩 *liang*	1/16 of market *jin* 0.0625 *jin* 10錢	
公斤 *gongjin*	Basic unit 10公兩		斤 *jin*	Basic unit 16兩	*exception
公衡 *gongheng*	10kg 10公斤		No counterpart in market system		
公擔 *gongdan*	100kg 10公衡		擔 *dan*	100 market *jin* 100 *jin*	
公噸 *gongdun*	1,000kg 10公擔		No counterpart in market system		