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ARTICLE

Promoting standardisation in modern China: British and American engineers' organisations, local Chinese engineers, and their transnational networks, 1901–41

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Abstract

Standardisation is a product of the second wave of the Industrial Revolution in Europe and North America. This article examines how Western standardisation practices were introduced, transmitted, and promoted in China during the first half of the twentieth century. In particular, it looks at the critical role played by British, American, and local Chinese engineers in the transmission process. The topics covered in the present article have seldom been considered, and this article tries to fill the gap in scholarship. It analyses the shifting patterns of various standardisation efforts that are closely related to the governance of both cities and the wider nation. Work examined includes that of the Engineering Society of China, led by British engineers, which initiated standardisation in the Shanghai International Settlement in the early twentieth century; that of the Association of Chinese and American Engineers, founded by engineers of China and the USA, which, after World War I, began to implement the standardisation of railway infrastructure, with the cooperation of the Ministry of Transportation of the Beijing government; and efforts in the 1930s under the Nanjing government to establish an 'engineering' or 'technocratic' state, which included the execution of national schemes for the development of industrial standardisation. From the period of World War I until the 1930s, the orientation and practices of American standardisation strategies dominated China; then, due to the worsening situation of the Chinese–Japanese War, ideological tendencies and national strategies for standardisation began to diverge.

Keywords: Chinese Institute of Engineers; Engineering Society of China; Association of Chinese and American Engineers; Engineering Society of Shanghai; internationalisation of China

Introduction

'Standardisation' is a product of the second wave of the Industrial Revolution in Europe and North America. It is based on the ease of interchangeability of standardised parts, which allowed modern factories to operate mass production methods and, as a result, changed the basic characteristics of modern production methods and industrialised societies; it also influenced the content of international economic and trade activities and the global transfer of technologies. Standardisation in modern China, as this article demonstrates, first benefited from the introduction of knowledge by the British-dominated foreign engineering community in Shanghai. After World War I, Chinese engineers who studied in the USA and American engineers worked together in China to promote the standardisation of railways, which was the beginning of the standardisation of Chinese industry. Further achievements of industrial standardisation were implemented in the

national industrial policy after the reunification of the Nanjing government, during which China's own engineers played an important role as the driving force of standardisation.

The issue of standardisation has received attention following the rise of global history and international history studies since the 1990s, with scholars focusing on how 'standardisation' and 'specification' in the field of engineering technology in modern Europe and the USA had global network-forming and industrialisation effects.[1] The development of standardisation around the world had its own particular significance. 'Standardisation' has been crucial to the promotion of industrial infrastructure and scientific management in modern China. However, previous research has rarely discussed the process of modern China's standardisation. This article tries to fill the gaps.

A concept similar to standardisation is 'scientification', although the latter has much wider connotations, and there have been a number of research monographs discussing the process of scientification in modern China. The book *American Science and Modern China, 1876–1936*, written by Peter Buck, focuses on the formation and construction of scientific knowledge in modern China from the perspective of American missionaries, the China Medical Board, and the Chinese Science Association.[2] Zhang Jian's monograph explores the extensive influence of the 'Chinese Science Society' (*Zhongguo kexueshe* 中國科學社) on the scientific system, knowledge production, and scientification in modern China.[3] But neither of these books mentions standardisation. The process of understanding 'standardisation' in the modern sense, and how to apply it, was clearly targeted and pragmatic, and could be seen as a technical practice of the scientific knowledge system in modern China.

This article explores the factors that led to the proposition and introduction of standardisation in China's most advanced city of Shanghai. It addresses how Western standardisation was introduced, transmitted, and promoted in China during the early twentieth-century global wave of standardisation through the transnational networks created by British, American, and Chinese local engineers. The project of standardisation was closely related to the governance of cities and the nation, and to be successful it had to be promoted by the government (both local and central): how did it gain traction in the national administration of the Chinese government and become part of the national policy plan, for the purposes of both localisation and internationalisation? In the process of industrialisation in modern China, at what level did the concept of standardisation begin to be discussed, and in which areas was it first implemented before gradually spreading to other fields? This article illustrates the role of transnational engineers in the standardisation process in modern China, and the incorporation of professional engineers into the technocratic system, making standardisation an important effect of state governance and expanding its significance in terms of infrastructure and administrative efficiency. The article ends with the outbreak of the Pacific War in December 1941, when the policy of industrial standardisation could not be sustained and came to a temporary end.

The introduction of standardisation by the British 'Engineering Society of China' in Shanghai

In the 1870s, the second Industrial Revolution flourished, and various new technologies and commodities were changing rapidly. In 1901, Britain was the first country in the world to set up a national standardisation organisation, namely the British Standards

[1] E. S. Rosenberg, *Transnational Currents in a Shrinking World* (Cambridge, MA, 2014); I. T. Berend, *An Economic History of Nineteenth-Century Europe: Diversity and Industrialization* (Cambridge, 2013).

[2] P. Buck, *American Science and Modern China, 1876–1936* (Cambridge, 1980).

[3] J. Zhang 張劍, *Sai xiansheng zai zhongguo—Zhongguo kexue she yanjiu* 賽先生在中國——中國科學社研究 *[Mr. Sai in China: A Study of the Chinese Science Society]* (Shanghai, 2018).

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Institution, then called the British Engineering Standards Committee (BESC), to develop and implement unified British Standards.[4] In the same year, British engineers' organisations in Shanghai, influenced by the engineering community in London, began to discuss standardisation.[5] This is probably the first time that a written record of discussions about standardisation was produced by a group of foreign engineers in Shanghai. The special background of the Shanghai Concession led the British-led engineering groups to aspire to making Shanghai a modern city that was habitable, progressive, and conducive to commercial prosperity; at the same time, the community of engineers was founded with the goal of enhancing the knowledge and practical experience of engineering, maintaining the professional standards of engineers, and establishing the norms of the engineering profession in China. We must first briefly introduce the British engineers' organisation established in Shanghai.

In January 1901, Gabriel James Morrison (1840–1905), a British engineer, founded a friendly organisation of engineers and architects in Shanghai. 'The Shanghai Society of Engineers & Architects'—the earliest association of engineers founded in China—had an initial membership of 85 and published an official journal in English. In 1912, in view of the increasing professionalism and refinement of modern engineering, architects decided to form a separate society to distinguish it from the engineering profession and, in 1912, the society was renamed the 'Engineering Society of Shanghai'. It was not until 1939, when the name in English was changed to the 'Engineering Society of China', that it gained a Chinese name for the first time (*Zhonghua guoji gongcheng xuehui* 中華國際工程學會). For the sake of discussion, this article refers to this organisation as the 'Engineering Society of Shanghai' (hereafter cited as the ESS).[6]

The ESS was founded at the end of the era of Queen Victoria (1819–1901)—the peak age of the British empire's expansion abroad after the second Industrial Revolution. In his inaugural speech as the first president of the ESS, Morrison highlighted the fact that the society was founded in the aftermath of the Boxer Rebellion as a sign that foreigners were not afraid of Chinese xenophobia, but instead continued to seek ways of technically elevating China as a civilised nation. Most of the successive presidents of the organisation worked for the Shanghai Municipal Council (SMC) or the Chinese Maritime Customs, and most of the members were initially engaged in public works such as water, gas, electricity, telephone networks, the Shanghai–Nanjing Railway, and the Huangpu River Dredging Bureau.[7] The membership was mainly from Europe and the USA but, in 1905, there appeared on the membership lists the first Chinese member, Zhan Tianyou (詹天佑 i.e. Zhan Tien-You), who would later be known as the 'father of modern Chinese engineering'. His experiences at the ESS made Zhan Tianyou expand his opportunities to meet with engineers from all over the world and, in 1913, he served as a model to establish a

[4] The BESC subsequently extended its standardisation work and became the British Engineering Standards Association in 1918. R. C. McWilliam, *BSI: The First Hundred Years: A Century of Achievement* (London, 2001). R. C. Allen, 'Why the Industrial Revolution was British: commerce, induced invention, and the scientific revolution', *The Economic History Review* 64.2 (2011), pp. 357–84.

[5] 'Engineering Standards', *The North-China Herald and Supreme Court & Consular Gazette*, 23 December 1904.

[6] Presidential Address by N. W. B. Clarke, *Journal of the Engineering Society of China, 1940–41*, pp. 1–2, 9–13. Xujiahui Collection, Shanghai; British Library, London. The official journal at the beginning was: *Engineering Society of China, report and proceeding* (hereafter cited as *ESCRP*). From October 1939, it changed to *Journal of Engineering Society of China* (hereafter cited as *JESC*) and the last volume was issued in May 1941, II.1.

[7] Regarding the history of the Shanghai Engineering Society, for more details, see Wu Lin-chun, 'Foreign engineers' activities in China and the process of China's internationalization, the case of the Engineering Society of China, 1901–1941', in *Chinas Development from a Global Perspective*, (ed.) M. D. Elizalde and Jianlang Wang (Newcastle upon Tyne, 2015), pp. 375–403.

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local engineering association in China—the Chinese Engineers' Association (*Zhonghua gongchengshi xuehui*中華工程師學會).[8]

The establishment of the BESC in London was a landmark in the global drive for industrial standardisation, and its actions became the basis for discussion of standardisation among the British engineering community in Shanghai. Just as the BESC was concerned with the electricity standardisation of urban cities in the beginning, the issue of urban electricity supply in Shanghai was also given the most attention by the ESS. In 1901, Charles Harpur, a member of the ESS, read out the progress of the work of the BESC, which had just been established in London, at the general meeting of the ESS.[9] In fact, as early as the early 1880s, the SMC authorised British merchants to set up an electric company in the Shanghai International Settlement: the Shanghai Electric Co., which was later taken over by the SMC due to the lack of lighting technology and operational problems. In 1893, the SMC established the Electrical Department of the Municipal Council (*Gongbuju dianqichu* 工部局電氣處), which began more than 30 years of self-management of the electricity industry in the Shanghai International Settlement.[10] Obviously, the SMC was well aware of the importance of electricity standardisation for urban development. Since, as mentioned above, most of the engineers in the ESS worked on public infrastructure, the topic of electricity standardisation was on the agenda as a priority for them.

In January 1914, urged by two engineers, R. A. Williams and J. S. S. Cooper, the ESS established the first Electricity Standardisation Committee. This committee claimed to represent great progress in China: 'This is a historic moment in electrical engineering, and if it succeeds in promoting this, it will not only have an impact on China, but will be ahead of the European and American countries, and there is no doubt that standardisation will be the world trend.'[11] However, although the ESS started to promote the standardisation of electricity in 1914, it was immediately interrupted. Due to the outbreak of World War I, in the summer of 1914, the first split was caused by the presence of members of different nationalities within the society, and the cooperative campaign to promote electricity standardisation was interrupted until the work was resumed after the war.[12] Cooper (of Arnold & Co.), the president of the ESS in 1917–18, wanted to not only promote the standardisation of electricity in Shanghai, but also recommend it to the newly established republican government of China. He believed that the main reason for the failure to implement electricity standardisation in China was not only the war, but also the lack of a stable and effective central government in China. He cited the following negative factors as being detrimental to the promotion of scientific industrial development in China: a confusing and inefficient regulatory system, neglect of technical experts, a shortage of engineering parts, the vastness of the territory and backwardness of transportation, the language barrier, old-fashioned customs, and other negative factors.

[8] Zhan Tianyou's membership in the organisation was not mentioned in any of the books compiled by Zhan Tianyou's chronicle. Zhan Tianyou was the first Chinese person to join the Shanghai Engineering Society, which was found by the author in the official information of the Society. See 'Note of History of the Society', *JESC* (1940–41), p. 20.

[9] 'Engineering Standards', *The North-China Herald and Supreme Court & Consular Gazette*, 23 December 1904.

[10] This situation remained unchanged until the founding of the US Shanghai Electric Power Company in 1929. Yan Yang 楊琰, 'Gongbu ju zhudao xia jindai shanghai dianli zhaoming chanye de fazhan' 工部局主導下近代上海電力照明產業的發展 [The development of the electric lighting industry in Shanghai, 1882–1893], 中央研究院近代史研究所集刊 *[The Bulletin of the Institute of Modern History, Academia Sinica]* 81 (2013), pp. 53–98.

[11] 'Electricity Standardization Committee', *ESCRP* (1915–16), p. 171.

[12] 'Report of the Council', *ESCRP* (1915–16), p. 73.

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A speech on 'The Engineer in China', presented by Cooper at the 'Shanghai Engineering Conference', expressed, on the one hand, an idealisation of the responsibility of foreign engineers to China and, on the other, the desire to nurture local Chinese engineers through engineering education. H. Von Heidenstam, a renowned Swedish engineer and chief engineer of the Shanghai Dredging Bureau (*Shanghai junpuju* 上海浚浦局), echoed the message, advocating that foreign engineers not only play the role of pioneers for the Chinese, but also assumed the role of models of European civilisation.[13]

Advocating standardisation may have been idealistic, but its coinciding with the interests of the British empire could not be avoided. The trend towards the standardisation of machinery and materials not only contributed to the commercial prosperity of Shanghai, but the standardisation of production and distribution lines in the various territories, colonies, and dependencies under the British empire would also help to consolidate and revitalise the rule of the empire. This in turn enhanced the interest of commercial engineers in investing in China. The newly developed industries in China before and after World War I (such as textiles, flour, and other machine-driven industries) presented enormous business opportunities, and the commercial engineers were most sensitive to the benefits of their investments in China. In July 1917, Charles Archibald Walker Rose, the British commercial representative in China, was interviewed by the editor of *Eastern Engineering*. He emphasised that the Great War had given rise to a number of new mechanised factories and that he hoped that Britain, with its manufacturing strengths and standardised goods, would be able to enter the Chinese market on a large scale. The diplomat argued that, although China's political reforms were not on track, the increasing number of Chinese students studying abroad was expected to change China educationally. Unlike more reserved British diplomats, he strongly advocated the need for British manufacturers to boldly open up business channels in China.[14] For the British, the overseas export of British standardisation could be considered as part of imperial rule, even though the British empire's pre-eminence would gradually decline after the end of World War I. In fact, it was due to the relative decline of British imperial power that they were thinking about industrial standardisation, not in terms of individual colonies or dominions, but as the simultaneous standardisation of the various colonies and settlements within the empire as a means of strengthening its power. In this way, they hoped, the development of intra-imperial trade could be accelerated, and the decline of the empire halted.[15]

The ESS continued to promote electricity standardisation in the 1920s, with the most important session of the 1922–23 meeting's panel discussion. The engineer E. A. Mills presented the special topic of 'Standardisation and the Urgent Need of Its Application to the Electrical Power Supply Industry in China'. He argued that, in the past decade, the demand for electricity supply in China had increased substantially, particularly in Shanghai. In China's city ports, in addition to the various foreign-owned or foreign-controlled power plants, different power machinery and facilities were imported, which made the standardisation of electricity more difficult. He proposed three major standards: first, a unified system of power supply; second, the use of a standard frequency; and third, the standardisation of voltage and volts.[16] The conference focused on the urgent need to

[13] J. S. S. S. Cooper, 'The engineer in China', *ESCRP* (1920–21), pp. 45–56.

[14] 'British trade in China: an interesting interview with MR. Archibald Rose, C. I. E.', *The Shanghai Times*, 13 July 1917, p. 9.

[15] 'Work of imperial conference: inter-imperial relations and industrial standardization problem', *The North-China Herald and Supreme Court & Consular Gazette*, 6 November 1926, p. 272.

[16] 'Standardization and the urgent need of its application to the electrical power supply industry in China', *ESCRP* (1922–23), pp. 121–30.

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address the efficiency, cost, and availability of voltage conversion for the industrialisation of Shanghai and China's city ports. The conclusion was that Shanghai, the 'Pearl of the Orient', should be an 'electricity standardisation' model for other cities in China, with an urgent need for its application to the electrical power supply industry.[17]

Discussion of the standardisation of electricity by the ESS faded in the 1930s. Although the society was still concerned about the establishment of standards in transportation, rail, water, and power supply engineering, they seemed to be increasingly wary of the political manoeuvring that might be involved in the question of how to develop infrastructure, such as whether Chinese standards should follow British or American technical routes, which could possibly appear as intervention in the governance of China's internal affairs. From 1933 to 1939, the biennial Presidential Addresses emphasised the moral and social responsibilities that engineers should have. When J. A. Ely, a professor at St. John's University in Shanghai, served as president (1933–36), he extolled the high responsibility of the engineering profession.[18] As Shanghai became a thriving international city, the membership of the ESS had grown to include members from other major Chinese cities and a small number of overseas members, and the organisation had transformed into a multinational and transnational association led by European countries.[19] After the 1930s, the ESS focused on education and the promotion of engineering disciplines, and the successive Presidential Addresses emphasised not only how to nurture the engineering profession, but also the pursuit of human welfare and the belief that engineers should maintain their duty in the face of world crises. We could say that, after the 1930s, the ESS experienced an awakening of its professional identity in China, with a greater emphasis on professionalism and responsibility. Although ESS members had no doubt about the superiority of European civilisation, they more often transcended the concept of nation-centeredness and emphasised the responsibility of engineers to the contemporary industrial and technological civilisation as a whole. This delicate shift was also relevant to the growing strength and professionalisation of the local Chinese engineering community after the 1930s, and to the industrial standardisation measures that were initiated by Chinese engineers who became technocrats for the Nanjing government.

The process of standardisation discussed by the ESS in Shanghai revealed the process of urban governance in the Shanghai International Settlement, closely associated with the British empire until the 1920s, but gradually moving towards Chinese localisation after the 1930s. It is noteworthy that the Presidential Address by A. J. Percival (of Percival, Inniss & Riddle, Ltd) at the Annual General Meeting of 1940, entitled 'Engineering Standards', praised China's growing indigenous engineering expertise and the improvement in engineering education. The speech offered good advice on standardisation in China, but not in the same way as in the 1920s when the Chinese were asked to follow British standardisation as pupils. The president's speech focused more on the importance of standardisation for modern China's industrial economy, and linked the responsibility of engineers to industrial standardisation as part of China's own national construction, rather than as an economic benefit to the British empire.[20]

[17] 'Discussion on standardization and the urgent need of its application to the electrical power supply industry in China', *ESCRP* (1922–23), pp. 130–38.

[18] The Presidential Address of 1933–35 was entitled 'Responsibility of Engineers in China'. The 1935–36 President's Address was entitled 'Duties & Responsibility of the Society' and the 1937–39 President's Address was entitled 'Social Responsibility of the Engineering'. See 'Note of History of the Society', *JESC* (1940–41), p. 50.

[19] *Ibid.*, p. 27.

[20] Presidential Address by A. J. Percival, 'Engineering standard', *JESC* (1939–40), pp. 1–3.

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The promotion of standardisation by the Association of Chinese and American Engineers in Beijing

Scholars have generally agreed that the USA made little contribution to industrial technological innovation before the 1880s, but was a true pioneer in business and factory management. In particular, Frederick Winslow Taylor (1856–1915), the father of scientific management in the USA, advocated for scientific management methods to improve production efficiency and implementation of the principles of standardisation (such as standardisation of tools, operations, labour actions, and other concepts). The National Bureau of Standards was established in 1901 by a proposal of the US Congress, and its earliest function was to serve as an inspection room for measurement standards; in 1903, it was formally attached to the Department of Commerce to promote standards and technology, with the goal of rewarding technological innovation to drive US industrial and commercial competitiveness in the international arena. The mass production method and technological innovation known as 'Fordism' was an important landmark in the development of globalisation in the twentieth century, with the use of specialised machinery and unskilled workers to produce a large number of standardised products.[21]

After the USA entered World War I, its proud achievements in industrial standardisation were thoroughly demonstrated. As an allied nation, standardised machinery and materials, effective industrial management, and the exchangeability of supplies made the issue of standardisation increasingly important. When Herbert C. Hoover became secretary of commerce and then president of the USA, he not only promoted standardisation there, but also attempted to establish the USA as an invisible empire in the global manufacturing system.[22]

At around the time of World War I, scientific management and standardisation promoted by the USA was jointly advocated by American-trained Chinese students and American engineers in China. While studying in the USA, the Chinese students had witnessed the fervent standardisation movement there and realised the remarkable results of scientific management in terms of human and material mobilisation during the Great War. Taylor's book, *The Principles of Scientific Management* (1912), translated by the American-returned student Mu Ouchu 穆藕初, was published in the *Journal of Chinese Industry* 中華實業界from November 1915 to March 1916. Soon after the outbreak of World War I, Mu Ouchu returned to China and founded the yarn factories of De Da and Hou Sheng, adopting Taylor's management method and becoming a model for other Chinese enterprises to learn from.[23] The American-returned students emphasised practical knowledge and technical specialisation, established a technical approach, and built a professional identity, believing that learning practical knowledge would promote industry.[24] 'Save the country by industrialisation' (*Shiye jiuguo* 實業救國) was the slogan of the returned students for building 'New China', and standardisation was undoubtedly the key to industrialisation.

A group of returned American students became pioneers in the construction of China's modern industry. Because of their similar engineering backgrounds and the ability to communicate in English, many of them joined the newly established Association of

[21] J. R. McNeill and W. H. McNeill, *The Human Web: A Bird's-Eye View of World History* (New York, 2003), p. 242.

[22] D. Immerwahr, *How to Hide an Empire: A History of the Greater United States* (New York, 2019), pp. 300–6.

[23] In 1909, Mu Ou-chu went to the USA to study and received a bachelor's degree in agriculture from the University of Illinois in 1913. He then attended the Texas Agricultural and Mechanical College to study the textile industry and received his master's degree in 1914. See Jiaxiu Mu 穆家修 (ed.), *Mu Ouchu xiansheng nianpu* 穆藕初先生年譜 *[Chronology of Mr. Mu Ouchu, 1876–1943]* (Shanghai, 2006), pp. 62–63, 84–85.

[24] Ye Weili, *Seeking Modernity in China's Name: Chinese Students in the United States, 1900–1927* (Stanford, 2001), pp. 56–67.

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Chinese and American Engineers (hereafter cited as the ACAE) and became important officers of the association. The ACAE was established in Beijing on 22 November 1919. Its objectives were as follows: I. To promote knowledge and practical experience in engineering. II. To maintain the professional standards of engineers, to cultivate the spirit of cooperation among peers, and to establish professional standards in engineering. III. To find feasible solutions to problems encountered in the ongoing engineering construction in China.[25]

At the beginning, there were about 100 members. The Minister of Transportation of China and the US Minister to China were honorary members. The core members of the ACAE came from the Ministry of Transportation, and the most important issue of concern at the beginning of the association was the unification and standardisation of railways. Since the end of the Qing Dynasty, most Chinese railways had been financed using foreign loans, particularly from England, France, Belgium, Germany, and Japan. In 1917, the Ministry of Transportation in Beijing established the Railway Technical Committee, which recruited technical experts from the Ministry of Communications and various road bureaus, as well as Chinese and foreign railway professionals, to work on the unification of railway planning.[26] At the inaugural meeting of the ACAE, the address by Communications Minister Ye Gongchuo 葉恭綽 focused on the urgency of road-building issues for the country's industrialisation, and the issue of railway unification was repeatedly brought up for discussion from the standpoint of technical experts.[27] The inaugural issue of the association's official journal (September 1920) described the progress of the Railway Technical Committee of the Ministry of Communications in the 'standardisation' of railways over the past two years of its existence. In a piece of Chinese text called 'Unification of Railroads' (*tongyi tielu* 統一鐵路), the same means to 'standardise' the railway, the president of the Railway Technical Committee, Shen Qi 沈琪 (also known as Shen Muhan 沈慕韓), paid tribute to the late engineer Zhan Tianyou's contribution to the promotion of railway standardisation, saying that the current stage of standardisation was to first examine the advantages and disadvantages of using different specifications for each section of the railway in China and find the best solution through the cooperation of foreign technical experts.[28]

The ACAE's advocacy for railway standardisation was jointly promoted by Chinese and American engineers, with many Chinese railway engineer members holding important positions. The best-known include: Ling Hongxun 凌鴻勛, a Chinese railway expert who graduated from Columbia University; Sun Duoyu 孫多鈺 of Cornell University, who served as the director of engineering of Zhuqin and Zhouxiang railways; Shi Zhaoxiang 施肇祥, assigned as the director of Bianluo Railway Bureau in 1919, who was an advisor of the Longhai Railway and served as the director of the Beijing–Han Railway in 1920; Cheng Xiaogang 程孝剛 of Purdue University, who, after returning to China, was engaged in railway construction for a long time and worked on many railways, including the Middle East, Jinpu, Jiaji, Beining, and Yuehan, etc., and served as the director of the Beijing–Han

[25] His-ling Hsiung, 'Introduction', *Journal of the Association of Chinese and American Engineers*, collected by Beijing National Library (hereafter cited as *JACAE*) I.1 (1920), pp. 1–3.

[26] Jui-te Chang 張瑞德, *Jindai tielu shiye guanli de yanjiu——zhengzhi cengmian de fenxi* 近代鐵路事業管理的研究——政治層面的分析 *[A Study of the Management of the Modern Railroad Business: An Analysis of the Political Aspects, 1876–1937]* (Taipei, 1991), pp. 5–6; Lin-chun Wu 吳翎君, *Meiguo daqiye yu jindai zhongguo de guojihua* 美國大企業與近代中國的國際化 *[American Big Business and the Internationalisation of Modern China]* (Taipei, 2012), pp. 170–75; E. Köll, *Railroads and the Transformation of China* (Cambridge, MA, 2019), pp. 53–90.

[27] 'Address of the Chairman at the opening of the First Civil Engineering Conference', *JACAE* I.1 (1920), pp. 12–14. 'Address of the Ministry of Communications at the opening of the First Civil Engineering Conference', *JACAE* I.1 (1920), pp. 14–16.

[28] 'The Commission on Railway Technics', *JACAE* I.1 (1920), pp. 6–11.

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Railway; Lehigh University's Yan Deqing 顏德慶, a railway engineer who served as deputy chief engineer and acting chief engineer of the Chuan–Han Railway; and Ohio Northern University's Deng Yiguang 鄧益光, director of public works for the Jiaji Railway and director of engineering for the Chengdu–Chongqing Railway. The ACAE's elite group of Chinese and American engineers worked closely with the Ministry of Transportation to initiate the standardisation of railways in the early 1920s.

In November 1920, the ACAE published an article about the importance of 'standardisation', mentioning that the mileage and layout of Chinese railways were still far from meeting China's needs and that most of the railway materials had to be imported. It was hoped that various countries with railway interests would adapt to China's local conditions, so that China could start to standardise the equipment requirements of its railways.[29] Although preparations for technical unification began in the early years of the republican China, the effect was mostly achieved after the establishment of the nationalist government in Nanjing, according to railway expert Ling Hongxun: 'Whether building roads or joint ventures with foreigners, no foreigners have been given to manage the railway standardisation, and all were conducted by domestic engineers. However, some areas' railways are not connected yet.'[30]

Members of the ACAE also included commercial engineers in new Chinese factories, who were initially promoting scientific management by replacing the traditional foreman system with a plant manager–engineer system, or professional engineers working in factories. It was also the goal of the association to visit new factories to observe the effectiveness of their scientific management. For example, at the annual meeting held in April 1922, a visit was arranged to the Housen Yarn Factory, which was run by Mu Ouchu, and a presentation on 'Comparison of Material Standards' discussed the great benefits of scientific management and the standardisation of commodity technology to the development of the industrial and commercial economy.[31] The process of standardisation was related to the business model of mechanised industry, the scientific management of new enterprises in large cities, and the rational management of machinery and materials, etc. The gradual emergence of new enterprises in big cities in China after the 1920s and the transformation of agriculture and industry in neighbouring cities seemed to predict the coming of standardisation in China sooner or later. Learning from the USA as the example of standardisation was reinforced by a special friendship between China and the USA in the 1930s, when standardisation was hotly discussed in the Chinese engineering community. However, seeing the future trend of standardisation in China, some foreign newspapers began to worry that China was overly inclined toward the American standardisation model that focused on efficiency in production and management. The Taylor-style scientific management of mass production could feed a larger Chinese population and improve convenient livelihoods, but could also lead to the simplification, homogenisation, and endlessly reproduced vulgarisation of the humanities, resulting in alarmist statements in the English-language newspapers in China.[32] In 1930, there was an article entitled 'China—Americanized?' in the *China Weekly Review.* It was mentioned that the American trend for scientific management and standardisation seemed to be conquering Europe at this time, and that this trend would blow into China as well. Was it possible for China to be Americanised? The article analysed in a meaningful way that the delicate handicraft techniques of the Chinese were quite close to the craft tradition of the Europeans, which

[29] 'Standardization', *JACAE* I.11 (1920), pp. 3–7.

[30] Hongxun Ling 淩鴻勛, 'Zhongguo tielu zhi jianshe' 中國鐵路之建設 [Construction of China railways], in Xue Guangqian 薛光前 (ed.), *Jianku jianguo de shinian [A Decade of Hard Work to Build a Nation]* (Taipei, 1971), p. 268.

[31] *Shen Bao* 申報 *[Shanghai News]* 4 April 1922, p. 13.

[32] 'Siegfried sees American ideal spreading fast', *The China Press*, 11 December 1929, p. 14.

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emphasised the creation of individuality, and it also warned China not to lose the value of refined traditional techniques in the adoption of the standardisation path.[33] These statements might be the result of the 'Americanisation' effect of the mass production of standardised goods and consumption patterns in the USA sweeping through Europe, leading some intellectuals to fear that the effect of American standardisation would erode the elegant and refined European civilisation.[34] However, for China, which had just started to proceed with the tasks and objectives of standardisation, there was no need to worry about the above issues.

After the 1930s, the mobilisation and dynamism of the ACAE were not as strong as they had been at its inception. The main reason for this was the gradual growth of local engineering associations in China, and the fact that many Chinese members of the ACAE were also important cadres of the Chinese Engineering Society, which naturally detracted from their participation in the ACAE. More importantly, the ACAE was established to help the Chinese develop their own team of engineers and was not in competition with the local Chinese engineers' associations. After 1935, the ACAE changed its official publication from every two months to a biannual journal, and membership declined to about 130.[35] The spread of knowledge and the promotion of 'standardisation' were finally fully advanced when a group of Chinese engineers—mostly from the ACAE or with American study experience—became technocrats for the Nanjing government.

The advocacy for standardisation by Chinese intellectuals and the implement of engineering technocrats in the Nanjing government

Although standardisation was introduced in the early twentieth century by the ESS and Taylor's scientific method of management was the subject of many publications during World War I, the discussion of standardisation and its adoption as a national policy in China only emerged after the founding of the Nanjing nationalist government, which formulated standards of weights and measures and related regulations in 1928–29. In 1931, the Industrial Standards Committee was established under the Ministry of Economic Affairs, and the first results began to be achieved.[36] At the same time, Chinese intellectuals were full of nationalistic passion to build up the country, and the call for industrial salvation made standardisation an important goal that urged the central government to make a decision. For the Nanjing government, which had just completed the unification of China, the standardisation of infrastructure and industrialisation were the most urgent needs. As William Kirby points out, the period of 1928–37 was the birth of China's move towards an 'engineering state' or 'technocratic rule', in which a group of technical experts began to plan China's infrastructure.[37] Wu Chengluo 吳承洛, a chemical engineer with an educational background in the USA, was a key figure in promoting industrial

[33] R. Leibrand, 'China—Americanized?', *The China Weekly Review*, 14 June 1930, p. 62.

[34] Since World War I, there have been many appeals for European countries to resist the phenomenon of American mass culture and commodity culture sweeping through Europe; even as early as the beginning of the twentieth century, French elites were deeply concerned about the phenomenon of Americanisation. For more details, see R. W. Rydell and R. Kroes, *Buffalo Bill in Bologna: The Americanization of the World, 1869–1922*, chapter 6 (Chicago, 2005), pp. 142–269.

[35] For more details, see Lin-chun Wu 吳翎君, *Meiguo ren weijing de zhongguo meng—qiye jishu yu guanxi wang* 美國人未竟的中國夢——企業、技術與關係網 *[America's Unfinished China Dream: Business, Technology and Relationships]* (Taipei, 2020), pp. 257–60, 291–99.

[36] *Special Issue of Chinese Institute of Engineers* 中國工程師學會會務特刊 *[zhong guogong cheng shi xue huihui wute kan]* IX.1 (1942), p. 7.

[37] W. C. Kirby, 'Engineering China: birth of the developmental state, 1928–37', in *Becoming Chinese: Passages to Modernity and Beyond*, (ed.) Wen-hsin Yeh (Berkeley, 2000), pp. 137–60.

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standardisation as a technocrat. He was a member of the ACAE and later a key member of the Chinese Institute of Engineers. After the establishment of the Nanjing government, he served as the director of the Bureau of Weights and Measures of the Ministry of Industry (1930), the director of the Central Industrial Laboratory, the director of the Industrial Department of the Ministry of Economic Affairs, and the director of the Trademark Bureau. Under the guidance of Wu and a group of technical experts, industrial standardisation was implemented under the national policy.[38]

As for the progress of standardisation in China, Chinese engineering experts also played an important role. The Chinese Institution of Engineers (*Zhonghua Gongchengshi xuehui* 中華工程師學會), founded by Zhan Tianyou in 1913, and the Chinese Engineering Society (*Zhongguo gongcheng xuehui* 中國工程學會), organised in 1918 by the engineering students of the Eastern USA, held a joint annual meeting in Nanjing in 1931, merging and changing their name to the Chinese Institution of Engineers (*Zhongguo Gongchengshi xuehui* 中國工程師學會).[39] At the founding of the Chinese Engineering Society, one of its aims was to 'standardise the construction of engineering and to prescribe a system of rules and regulations so that there will be no discrepancies in the standards', and the concern for standardisation originated from a very early stage. At the 1926 Beijing Annual Meeting, Clark (full name unknown), an American mechanical engineer, was invited to give a lecture on 'The Standard Law'.[40] In early 1931, Xu Peihuang 徐珮璜, the president of the Chinese Institute of Engineers, proposed to the government to 'request the Ministry of Industry and Commerce to set national production standards'. In March of that year, the Ministry of Industry sent a letter to the Chinese Institute of Engineers, hoping to dispatch a representative to assist in the development of industrial standardisation, and a Preparatory Committee for Industrial Standards (*Gongye biaozhun choubei weiyuanhui* 工業標準籌備委員會) was established within the institute to promote industrial standardisation from a civil perspective. One member, Yun Zhen 惲震, made important contributions to the development of electricity standards, drafting the 'Regulations on Frequency and Voltage Levels of Chinese Power Standards'. The annual meeting of the Chinese Association of Engineers had also discussed the issue of power standards as a special topic.[41]

Standardisation was promoted not only in technical and business administration, but also in national personnel management. In 1931, W. F. Willoughby wrote an article entitled 'Classification and Standardisation of Salaries', which was translated by Gu Youcheng 古有成 and published in the *Zhejiang Civil Affairs Monthly* (*Zhejiang minzheng yuekan* 浙江民政月刊) Willoughby was the president of the American Political Science Association from 1931 to 1932. As his book mentioned, the joint session of the US Congress in 1920 approved the classification of the activities and services of the US

[38] For the details of Wu Chengluo's life and his contribution to the system of weights and measures and the promotion of industrial standardisation, see Miao Wu 吳淼, *Wu Chengluo yu zhongguo jindaihua Jincheng* 吳承洛與中國近代化進程 *[Wu Chengluo and the Progress of Modernisation in China]* (Shanghai, 2011), pp. 107–33.

[39] Chengluo Wu 吳承洛, 'Sanshi nian lai zhongguo zhi gongchengshi xuehui' 三十年來中國之工程師學會 [The Chinese Society of Engineers for the past 30 years], in Zhou Kaiqing 周開慶 (ed.), *Sanshi nian lai zhi zhongguo gongcheng* 三十年來之中國工程 *[Thirty Years of Chinese Engineering]*, vol. 2 (Taipei, 1969), pp. 9–13; Z. Fang 房正, *Jindai gongchengshi qunti de minjian lingxiu——zhongguo gongchengshi xuehui yanjiu* 近代工程師群體的民間領袖——中國工程師學會研究, 1912-1950 *[The Civil Leaders of Modern Engineers: A Study of the Chinese Engineers' Association, 1912–1950]* (Beijing, 2014), p. 61.

[40] 'Zhonghua gongchengshi hui jianzhang' 中華工程師會簡章 [The Chinese Society of Engineers' regulations, 1913], *Zhonghua gongchengshi hui baogao* 中華工程師會報告 *[Report of the Chinese Society of Engineers]* 1 (1913).

[41] Zhen Yun 惲震, 'Dian li dian gong zhuan jia yun zhen zi shu (yi)' 電力電工專家惲震自述(一) [Autobiography of power electrician expert Yun zhen], *Zhongguo keji shiliao* 中國科技史料 *[Historical Materials of Chinese Science and Technology]* 3 (2000), pp. 197–98.

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government into 44 different types and the standardisation of civil service salaries for improving the administrative system of government employment and its management efficiency.[42] In addition, a political economist, Gan Naiguang 甘乃光, who studied in the USA, advocated founding the 'Administrative Efficiency Research Institute' (*Xingzheng xiaolü yanjiuhui* 行政效率研究會) in 1934, which included 'Principles of Public Administration' by Leonard White and W. F. Willoughby of the University of Chicago, one of the leading figures in public administration in the USA, as a guideline for reforming public administration in China. This advocate for managing public service was later supported by the nationalist government.[43] The idea of introducing American public management theory to China and establishing an efficient personnel administration echoed the call for standardisation at the time, showing how Chinese intellectual circles in the early years of the Nanjing government had correspondingly advocated for the standardisation of personnel administration and the building of a modern state.

In the 1930s, the government and the intellectual community supported each other, and the central government and the private sector advocated industrial standardisation as an ideological and practical movement that would lead the country to prosperity and progress. The publisher Wang Yunwu advocated the benefits of 'standardisation'. Wang gave lectures on the principles of scientific management at the Banking Association, University Business School, and YMCA.[44] There were also many articles that focused on the 'standardisation of goods' and standardisation of production.[45] The scope of industrial standardisation was noted and the effectiveness of standardisation in Germany, the USA, the UK, and Japan was initially described.[46] 'The Business of Commercial Standardisation in the United States and Its Value', which was published by the Bureau of Standards of the US Department of Commerce on 20 March 1930, had been swiftly translated by Yin Shizhu 殷師竹 and appeared the following year in the *Commercial Monthly*, just before the Nanjing government's Industrial Standards Committee was established. That translated article detailed the origin, purpose, scope, and procedures of the US government's promotion of commercial standardisation, including examples of certification, various question-and-answers, and illustrations. These details illustrated a teaching manual on American commercial standardisation.[47]

Wu Chengluo, who was responsible for planning and promoting the standardisation policy, wrote several articles related to industrial standardisation in the 1930s. He introduced in detail the progress of industrial standards in Britain, the USA, France, Germany, the Soviet Union, and Japan, and discussed the need for China to implement industrial

[42] *Zhejiang minzheng yuekan* 浙江民政月刊 *[Zhejiang Civil Affairs Monthly]* 47 (1931), pp. 9–14; 48 (1931), pp. 5–10; 49 (1931), pp. 9–17; 50 (1932), pp. 9–13.

[43] Naiguang Gan 甘乃光, 'Xingzheng xiaolü yanjiuhui sheli zhi zhiqu' 行政效率研究會設立之旨趣 [The purpose of establishing the Administrative Efficiency Research Institute] (published on 1 July 1934), in Naiguang Gan, *Zhongguo xingzheng xinlun* 中國行政新論 *[A New Theory of Chinese Administration]* (Beijing, 1943), p. 44.

[44] Yunwu Wang 王雲五, 'Gongye biaozhunhua' 工業標準化 [Industrial standardisation], *Shanghai qingnian zhoukan* 上海青年週刊 (published by Shanghai YMCA) 30.43 (1930), pp. 1–4; Yunwu Wang, 'Gongye biaozhunhua' [Industrial standardisation], *Fangzhi shibao* 紡織時報 *[Textile Times]* 760 (1930), pp. 2–3, 6–7.

[45] 'Wupin biaozhunhua' 物品標準化 [Item standardisation], *Ran zhi fang zhoukan* 染織紡週刊 *[Dyeing & Weaving Weekly]* 780 (1933), pp. 145–46; 'Chupin biaozhunhua' 出品標準化 [Production standardisation], *Tielu yuekan* 鐵路月刊 (Jing hu 京滬, Hu hang yong 滬杭甬) *[Railroad Monthly]* I.27 (1936), p. 417.

[46] Boqiao Yang 楊伯僑, 'Gongye biaozhunhua' 工業標準化 [Industrial standardisation], *Gongye biaozhun yu duliangheng yuekan* 工業標準與度量衡月刊 *[Monthly Journal of Industrial Standards and Weights Measures]* II.7 (1936), pp. 1–4.

[47] Shizhu Yin 殷師竹, 'Meiguo zhi shangye biaozhunhua shiye ji qi jiazhi' 美國之商業標準化事業及其價值 [US business standardisation and its value], *Shangye yuebao* 商業月報 *[Business Monthly]* 11.11 (1931), pp. 1–13; 11.12 (1931), pp. 1–12.

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standardisation and set up related institutions.[48] Wu explained the process of the standardisation movement and its impact on the Industrial Revolution and the movement of economic standardisation, revealing standardisation as an indicator of the development of civilisation from the historical development of Europe and the USA to imply that China must face the world, and emphasising that the Industrial Revolution was inseparable from the standardised economy.[49]

In May 1931, the Chinese Industrial Standards Committee's charter was approved by the Ministry of Industry, and more than 200 members were appointed, divided into five groups: civil engineering, electrical industry, dyeing and weaving industry, chemical industry, and iron and metallurgical industry (the charter was amended to add a group for the agriculture and forestry industry). In 1932, the affairs of the Industrial Standards Committee were transferred from the Department of Industry to the National Bureau of Weights and Measures, and a special technical office was set up to recruit experts who had studied in England, the USA, Germany, France, Russia, and the Soviet Union, and even to find staff who had served in the Dutch, Italian, and Swedish diplomatic missions to translate the standards of various countries. In 1935, the compilation of Chinese standards began, and the first act was to choose CIS (the abbreviation for Chinese Industrial Standards) as the symbol of Chinese standards in order to exchange with countries worldwide.[50]

As the government's main technocrat for promoting standardisation policy, Wu Chengluo explained how the national government started the process of industrial standardisation, from the preparation, trial application, and implementation to the effectiveness and future challenges of various government departments.[51] Wu Guozhen 吳國楨, who was the mayor of Hankou, wrote 'Industrial Standardisation and the Future of Metric Unification', which strongly advocated the successful achievements of the US Bureau of Standards under President Hoover as an inspiration for China's economic development.[52] To promote industrial standards and weights and measures, the Ministry of Industry published the *Monthly Journal of Industrial Standards and Weights Measures* (*Gongye biaozhun yu dulianghen yuekan* 工業標準與度量衡月刊) in July 1934. The 'Preface' of the journal, written by the former minister of industry, Chen Gongbo 陳公博 (the minister of industry from 1931 to 1932), explained that the development of China's industry must be preceded by the search for uniform weights and measures and industrial standards to lay the foundation. The publication not only served as a guide to the policy and guidelines, but also introduced international developments in standardisation and rationalisation of management.[53]

[48] Chengluo Wu 吳承洛, 'Gongye biaozhunhua (I)' 工業標準化 [Industrial standardisation], *Gongye zhongxin* 工業中心 *[Industrial Centre]* II.4 (1933), pp. 73–75; Chengluo Wu, 'Biaozhunhua yundong zhi guocheng ji qi duiyu gongye geming jingji tongzhi yu kexuehua yundong zhi yingxiang' 標準化運動之過程及其對於工業革命經濟統制與科學化運動之影響 [The process of the standardisation movement and its impact on the Industrial Revolution economic system and the scientific movement], *Kexue de zhongguo* 科學的中國 *[Science in China]* 2.9 (1933), pp. 3–7; Chengluo Wu, 'Zhongguo gongye biaozhunhua zhi huigu ji jinhou yingcai tujing zhi niyi' 中國工業標準化之回顧及今後應採途徑之擬議 [A review of industrial standardisation in China and the proposed approach for the future], *Gongcheng* 工程 *[Engineering]* 15.1 (1942), pp. 7–13; 15.2 (1942), pp. 21–32.

[49] Chengluo Wu 吳承洛, 'Zhongguo gongye biaozhunhua zhi huigu ji jinhou yingcai tujing zhi niyi' 中國工業標準化之回顧及今後應採途徑之擬議 [A review of industrial standardisation in China and the proposed approach for the future], *Yu min*裕民 *[Wealth of the People]* 5 (1943), pp. 9, 12.

[50] *Ibid.*, pp. 15–16.

[51] *Ibid.*, pp. 12–23.

[52] Guozhen Wu 吳國楨, 'Gongye biaozhunhua yu dulianghen yi zhi qiantu' 工業標準化與度量衡一之前途 [The future of industrial standardisation and metric unification], *Gongye biaozhun yu dulianghen yuekan* 1.4 (1934), p. 1.

[53] Gongbo Chen 陳公博, 'Fakan ci' 發刊詞 [Foreword of initial issue], *Gongye biaozhun yu dulianghen yuekan* 工業標準與度量衡月刊 1.1 (1934), pp. 1–3.

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Furthermore, it could be considered as the central government's national plan to initiate industrial standardisation through a more elaborate propaganda approach.

Compared with advanced industrial countries such as Europe, the USA, and Japan, China was relatively backward in terms of infrastructure and technology development, and, with factors such as political instability, vast land area, and limited institutional concepts, the local implementation of standardisation policies was quite challenging. After the outbreak of the Sino–Japanese War, the nationalist government's efforts to promote industrial standardisation were hampered by transportation barriers, lack of manpower, and the enormous damage caused by the war. In marked contrast, after the Japanese occupation of Manchuria, the Manchurian Electric Power Company was established to control and monopolise the resources of the Manchurian areas and to strengthen the industrial construction goals of the Japanese empire.[54] After the Japanese invasion of China, the need to standardise the manufacture of weapons and armaments for the defence industry became urgent. There was a slogan: 'Only sharp weapons can destroy the enemy; only a large number of replenishments can lead to lasting victory.'[55] In the midst of the turbulence of war, the Chinese Institution of Engineers established the Industrial Standards Association in Guiyang in October 1941, with Ling Hongxun 凌鴻勛 as the president and Wu Chengluo as the vice-president, and it officially started to operate on 15 January of the following year. The association drew up a draft of the 'Aims of the Chinese Institution of Engineers' Campaign for Industrial Standardisation', which was revised by the Board of Directors and Weng Wenhao 翁文灝, director of the Economic Resources Committee and president of the Chinese Institution of Engineers, and published it as the first part of the 'Series of the Chinese Engineering Standards Association', followed by the proposed development of provisional standards suitable for Chinese domestic industries.[56]

The campaign for industrial standardisation was about the effectiveness of the Nanjing government in promoting industrial construction internally and the significance of China's efforts to converge with the industrial standards of the world's advanced countries externally. In fact, it was not until 1926 that the International Federation of the National Standardising Associations (ISA) was formally established. In 1934, a conference of the International Standardisation Association was organised by the Swedish Committee and held in Stockholm, with a total of 24 countries and about 100 participants. The conference facilitated discussions and communication between engineers from different countries on international industrial standardisation issues such as Ball-Bearing, an international system of tolerance limits and fits, aviation igniter patterns, etc. Unfortunately, all these works were halted by the outbreak of World War II.[57]

[54] Zhizhong Jing 井志忠, 'Manzhou dianye zhushihuishe shimo' 滿洲電業株式會社始末 [History of Manchurian Electric Co.], *Waiguo wenti yanjiu* 外國問題研究 *[Research on Foreign Issues]* 2 (2011), pp. 3–11.

[55] See '惟器利，方可摧堅敵銳；惟大量補充，方可持久致勝' in Chao Huang 黃超, 'Gongye biaozhunhua yu guofang' 工業標準化與國防 [Industrial standardisation and national defence], *Gongye biaozhun yu dulianghengyuekan* 2.9 (1936), pp. 1–5. In addition, in the early 1930s, the nationalist government's standardisation drive in the military industry was clearly influenced by Germany, but this article focuses on the British and American engineer networks and fails to capture the German influence. Hans V. Seeckt, a German military advisor, prepared the 'Report on the Reorganization of the Chinese Army', which shows that the standardisation of the nationalist government's military defence in the early 1930s was influenced by the German side. See W. C. Kirby, *Germany and Republican China* (Stanford, CA, 1984).

[56] 'Zhongguo gongye mou biaozhunhua, gongcheng biaozhun xiejinhui chengli' 中國工業謀標準化、工程標準協進會成立 [China industry seeks standardisation, engineering standards association established], *Zhongguo gongchengshi xuehui huiwu tekan* 中國工程師學會會務特刊 *[Special Issue of the Chinese Engineers' Association]* 9.1 (1942), p. 7.

[57] Wei-han 維翰 (trans.), '1934 nian guoji biaozhunhua huiyi gaikuang' 1934年國際標準化會議概況 [Overview of the 1934 International Conference on Standardisation], *Gongye biaozhun yu dulianghengyuekan* 2.3 (1935), pp. 27–30.

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After the 1930s, the Chinese Institution of Engineers began to participate in international engineering conferences, and international standards became a hot topic of discussion among transnational engineers. For example, in 1931, the World Power Association Conference held in Berlin, Germany, was attended by members led by Huang Boqiao 黃柏樵, president of the Shanghai Branch of the Chinese Engineering Society. The Chinese delegates felt that 'in the future, the supply of power in the world will gradually become more and more international, so that the technology and economy can be more fully developed'.[58] In 1936, the third World Power Association Conference was held in Washington, DC. The Chinese delegates presented six papers at the conference, which also dealt with the adoption of international standards.[59]

After the end of World War II, international standards became more and more important to the coordination of countries around the world, and China entered a new stage of negotiation with the United Nations and other international organisations in the process of standardisation.[60] A new global standards body was established at the suggestion of the United Nations Standards Coordinating Committee (UNSCC). In October 1946, representatives of 25 countries from the ISA and UNSCC gathered in London and agreed to create a new International Organisation for Standardisation (ISO). In March 1947, the Nanjing government's Industrial Standards Committee and the National Bureau of Weights and Measures were merged to form the Central Bureau of Standards of the Ministry of Economic Affairs, which gradually planned the convergence of domestic standards with the international standardisation system and promoted the standardisation project to a new milestone.[61]

Conclusion

When standardisation was first introduced into China, two British and American-led engineers' organisations, one in the north and one in the south, each involved in the governance of urban (SMC) or central government, were able to spread or guide the process of standardisation in modern China through their activities. The ESS was a pioneer in the introduction of standardisation, with priority given to the standardisation of electricity in the Shanghai Concession. The ACAE, whose members mostly worked for the Ministry of Transportation, had focused most on the standardisation of Chinese railways, demonstrating the different concerns of the two associations. The reason was that the issue of railway standardisation in China had much to do with the various rights and interests of the Great Powers in building Chinese railways; and, more importantly, it was about the authority of the central government in Beijing and its executive capability, which

[58] Yu-gan 育幹, 'Shijie dongli huiyi' 世界動力會議 [World Power Conference], *Dongfang zazhi* 東方雜誌 *[The Eastern Miscellany]* 27.16 (1930), pp. 5–7.

[59] Peiyuan Ren 任培元, 'Shijie dongli huiyi' 世界動力會議 [World Power Conference], *Zhongguo dianli* 中國電力 *[China Power]* 1.1 (1937), pp. 55–57; 'Zhongguo gongchengshi xuehui ershisi niandu huiwu zongbaogao: guanyu tuipai daibiao canjia shijie dongli xiehui huiyi shixiang' 中國工程師學會二十四年度會務總報告：關於推派代表參加世界動力協會會議事項 [The 24th Annual General Report of the Chinese Institute of Engineers: About Sending Delegates to the World Power Association Conference], *Gongcheng zhoukan* 工程週刊 *[Engineering Weekly]* 5.10 (1936), p. 3.

[60] International Organization for Standardization (ISO), https://www.iso.org/home.html (accessed 1 September 2023).

[61] Zhongyang biaozhunju 中央標準局, *Zhongyang biaozhunju gaikuang mulu* 中央標準局概況目錄 *[Central Bureau of Standards Catalogue]* (Nanjing, 1947), p. 1. 'The quarterly Industrial Standards Bulletin', published in 1944–1946, was published as 'Standards' in 1947–1948. The Central Bureau of Standards established an office in London to strengthen international standards liaison.

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was not the main concern of the ESS, whose members worked for the SMC. After the outbreak of the Pacific War, these two engineering groups were both suspended.

After World War I, the Chinese intellectual community enthusiastically cited the standardised experience of American industrial and commercial development, and new Chinese enterprises began to adopt American scientific and standardised management, while American standardisation prevailed in China as American investment in China increased after the 1920s. The Chinese intellectual community in the 1930s was obsessed with standardisation from both theoretical and practical points of view, in order to urge the nationalist government to implement the goals of economic construction and industrialisation, and to move into the international arena with the features of a modern state. The spirit of mass production and efficiency that characterised the American standardisation movement raised concerns among Europeans at the time that the result would be an erosion of refined civilisation. European warnings that American-style standardisation in China might lead to the 'Americanisation of China' did not worry the Chinese intellectual elite of the time. The close and friendly relationship that developed between Chinese and American engineers after World War I was a crucial and important factor. During this period, from the Beiyang government to the Nanjing government, American engineers played the role of friendly mentors, helping China to train its own engineers and specialists for promoting modern China's industrialisation.

The earliest implementation of 'standardisation' in Europe and the USA was initiated by local professional engineer groups, which led to the formation of a trend that was then adopted by the government, and China was no exception. The growth of local engineers in China since the 1930s not only indicated the growth of a new group, but also revealed that 'engineer' was becoming a recognised professional identity in China, and was linked to the aspirations of national construction and social responsibility. It was only in the early days that the European and American engineering groups, either consciously or unconsciously, played the role of mentors in China or tried to link standardisation for their imperial trade purposes. However, after the 1930s, as the engineering profession in China became localised and influenced by the rise of Chinese nationalism, both associations—the ESS and the ACAE—had returned to the professional discussion of academic engineering, rather than the earlier interest of outsider groups in the policies of their home countries. The ACAE was not only important to the unification of the railways; most of the Chinese members who worked for the Nanjing government, including Wu Chengluo, also came from this organisation. It was China's own technical talents who were transferred into the nationalist government system, and many of them had studied abroad and had an international perspective. Under the guidance of the Industrial Standards Committee, the standardisation policy was implemented according to the needs of China's real conditions and with reference to international standards. Finally, the scientific management of 'efficiency' (*xiaolü* 效率) began to transform into the level of rationalisation of bureaucracy, and the initial results were achieved through the combination of ideas and policies.

Last but not least, the author has also noted that the perilous situation after the outbreak of the Pacific War highlighted the difficulties of national economic mobilisation and the importance of defence and industrial enterprises. At around the end of World War II, the discussion of standardisation in China did not rely on the bottom-up experience of unification, production, and consumption methods, and the efficiency of business administration in the process of standardisation in the USA, as it did from World War I to the 1930s. In 1944, the Industrial Standards Committee of the Ministry of Economic Affairs issued a quarterly publication called the *Industrial Standards Newsletter*, which revealed the determination to promote the rationalisation campaign that started in Germany after World War I. The campaign was extended from the military industry to various

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industries.[62] The special article of the *Industrial Standards Newsletter* gave much recognition to Germany's success in industrial standardisation and scientific management after World War I and its rapid economic recovery, as well as to Germany's amazing mobilisation in military industry and civilian goods at the beginning of World War II. In addition, it also affirmed the success of the Soviet Union's three-year and five-year planned economy, which served as a blueprint for the postwar nationalist government to accelerate the national planned economy.[63] Although the journal had also widely promoted an overview of standardisation in various countries, it was not as enthusiastic as the pre-1930s approach and steps of American standardisation and scientific management. The critical situation in China after the Pacific War, and the tendency to centralise power, caused a subtle shift in the ruling ideology involved in promoting standardisation, which ultimately came down to internal and external adaptations at the national governance level to accomplish specific goals of nation building. The implementation and ideological connotations of standardisation in China after the Pacific War, as well as postwar developments, are beyond the scope of this article and require further study.[64]

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[62] Xian-de Xiang 向賢德, 'Tezai: gongye biaozhunhua' 特載：工業標準化 [Special Issue: Industrial standardisation], *Gongye biaozhun tongxu* 工業標準通訊 *[Industry Standard Communications]* 1 (1944), pp. 23–30.

[63] Xian-de Xiang 向賢德, 'Te zai: woguo gongye jianshe ying yi tuixing gongye biaozhunhua wei xianwu' 特載：我國工業建設應以推行工業標準化為先務 [Special Issue: Industrial standardisation should be the first priority in our industrial construction], *Gongye biaozhun tongxun* 3 (1945), pp. 21–23.

[64] The author's preliminary view was that the USA relied heavily on the opinions of various civilian committees to promote industrial standardisation in the early twentieth century, and that this idea should run counter to the postwar attempt of a nationalist government to strengthen the spirit of national power and develop defence industries. However, further research will be needed.

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