

**FOSTERING INNOVATIONS AND TECHNOLOGICAL DEVELOPMENT DURING
THE MEIJI: SOME OBSERVATIONS ON THE ADAPTABILITY OF JAPANESE
CULTURE**

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INTRODUCTION

The article deals with how Japanese culture—language and education in particular—facilitated the diffusion of foreign technology during the Meiji, one of the most important periods in Japanese history. It gives examples of some aspects of Japanese culture that favored the entry of foreign technology during Japan’s Westernization and modernization periods. These two processes also shaped Japan’s educational system, and explain sociologically the nature of Japanese culture.

Focusing on language, the article gives some historical explanations of how the linguistic capability of the Japanese developed. It describes how such capability helped foster technological transfer and eventually brought about the economic and technological growth of Japan during the Meiji and beyond.

Using culture as an explanatory variable for technology transfer has limitations in accounting for the real factors behind the successful diffusion of technology from the West to Japan. Nevertheless, the article highlights many instances of cultural adaptability in the history of Japan’s technological development.

This article examines the adaptability of the Japanese to adapt to influences brought about by modern Western technology. It suggests the advantage of an ingenious or practical ability to adjust to change without losing one’s sense of identity or balance. It argues that the adaptability of Japanese culture shows in its ability to respond to changing conditions, make innovations, and, at the same time, maintain its *Japaneseness*.

This article presents observations of Japanese cultural adaptability during the Meiji (1868–1912), particularly in shipbuilding and chemical industry. The two reasons why the Meiji is the only focus of the article are: first, modernization during the period is a culmination of many centuries of indigenous as well as modern innovations in science and technology; and, second, it was in that era that the so-called old Nihongo (term for the Japanese language) of previous empires became more understandable to the common population through the elimination of abstract Chinese characters, vague pronunciations and erudite semantics of the elite Tokugawa class and Heian language. The discussion on adaptability, however, unavoidably touches on the preceding and subsequent eras due to the encompassing nature of the topic. Some relevant points

from other centuries may strengthen the hypothesis that the adaptability of Japanese culture took root many years before the Meiji. The article's focus is on aspects of culture, namely, language and education, where adaptability is most evident. The Japanese language manifests many Japanese innovations for assimilating technology, while education expresses the Japanese philosophy of modernization as well as Westernization. Both language and education appear to have been responsible for the successful transfer of foreign technology to Japan and the country's subsequent economic development.

To represent the article's hypothesis, Figure 1 shows the relationship between modernization, assimilation of Chinese culture, development of the Japanese writing system, and receptivity of the Japanese language to foreign words. The Japanese acquired many Chinese terms and characters. The terms later provided the Japanese with a vocabulary base by which foreign technical words could be easily understood and assimilated into the native language. The Japanese writing system, which was derived from the Chinese system, also helped in the absorption of Western terminology as the Japanese were able to translate foreign technical words through the use of Chinese characters. Such acquisition subsequently equipped Nihongo with the receptivity to loanwords and foreign technical concepts and led to the modernization or Westernization of Japan.

Many books and journals about the Japanese language and technology during the period under study discuss language and technology as separate topics. Some expound only the relationship between economic development and technological innovation systems. Although a few articles mention the cultural adaptability of the Japanese, none have tried to delve on the particular contribution of language to the technological development of the Meiji. As far as modernization is concerned, the available books on culture described only the influx of foreign loanwords into the Japanese language and social concepts as a result of Westernization, but did not examine how language as an aspect of culture facilitated the entry of foreign technology. The writer believes that this is the first article to explain and stress the importance of Nihongo in the development of technology during Japan's crucial economic take-off stage, the Meiji.

THE EDUCATIONAL POLICY OF THE MEIJI GOVERNMENT

The Meiji government's basic educational policy was based on Article Five of the Imperial Oath, which states that knowledge shall be sought throughout the world so that the welfare of the empire may be promoted. Article Five specified the goal of modernizing national education through the introduction of modern Western civilization. The Meiji government's policy to develop education for all the people was founded on the concept of civilization and enlightenment as leading to the creation of a strong modern nation. Thus, the government assumed direct control of all national educational institutions and promoted schooling for the general populace so as to attain the objective of introducing Western culture and developing leadership among the students. In 1871, after abolishing the fiefs and establishing prefectures, the new government established the Department of Education and placed it in charge of all the

nation's educational activities. It also promulgated the Education System Order, which aimed to establish a modern educational system.

The objective of putting up higher educational institutions was chiefly to offer leadership training to meet the demands of the new age and to address the urgent task of assimilating Western arts and sciences. Some institutions that the Meiji government restored primarily for Western learning were the Shōheizaka Gakumonjo, Kaiseijo, and Igakugo (former schools of the Tokugawa Shogunate). The Shōheizaka Gakumonjo became the nation's highest institution of education and learning. The three schools later comprised the Grand School (Daigakkō), which was renamed the University (Daigaku) in 1870 to become the central organ for educational administration.

The University consisted of colleges that followed Western instruction. At the Southern College of the University, students in regular courses (where study was conducted in Western languages) were taught by foreign teachers and those under irregular courses (where Japanese was the medium of instruction), by Japanese teachers. Similarly, at the Eastern College of the University, students of regular courses studied using Western languages and students of irregular ones studied Western textbooks that had been translated into Japanese.

Elementary and middle-level schools focused on science. Under the 1880 Education Order, the elementary level's higher course consisted of arithmetic, chemistry, physiology, geometry, and economics among others. For the middle level, specialized schools were set up by each prefecture. The primary course consisted of subjects such as arithmetic, algebra, geometry, geography, physiology, zoology, botany, physics, chemistry, economics, bookkeeping, and drawing among others. For the university level, Tokyo University in 1877 started with four faculties, namely Law, Science, Literature, and Medicine. The Faculty of Science had several departments: chemistry, physics, mathematics, astronomy, biology, engineering, geology, and mining.

The Meiji leaders strongly believed that, aside from appointing foreign teachers to Japanese schools, sending students abroad for research was necessary in speeding up Japan's modernization. Table 1 shows the number of students sent abroad by the Ministry of Education, by year and type of program. The table indicates that as the idea of civilization and enlightenment gained ground in Meiji Japan, the government acquired a more positive view of overseas inspection tours and foreign schooling, resulting in the considerable increase in traffic between Japan and the West.

An important development toward the training of leaders was the system of "dispatched students from fiefs" or *kōshinsei*. Under this system, able students between 16 and 20 years old were sent by fiefs to the colleges of the University. They underwent instruction in English, French, and German languages. This instruction in various languages was believed to assist in developing the abilities of students to lead in Japan's modernization.

The interest of the Japanese in Western ideas was remarkable. A huge amount of original works and translations on Western life and thought, as understood by contemporary scholars of the West and native leaders of the civilization and enlightenment movement, were published.

Magazines and news articles emphasizing civilization and enlightenment themes were printed too.¹ Fukuzawa's school, called Keiōgijuku, and other private schools were oriented toward Western learning. They played a very important role in the popular movement to realize modernization.

Both the translation of technical works and the creation of schools offering technical courses continued the modernization policy. By 1874, the Department of Education, which undertook the task of translating, editing, and publishing many imported scientific books from Europe and America, had issued 51 works totaling 132 volumes. Its work was significant in either creating or standardizing tens of thousands of technical terms in all fields, namely, philosophy, law, economics, psychology, physics, and chemistry among others. As will be seen later, the translation of scientific books had important ramifications for the overall development of education, science, and culture.

The Meiji government strongly believed in the crucial role that education played in Japan's technological growth and rapid industrialization. Thus, it pursued modernization of the nation's educational institutions by adopting Western models of learning, employing foreign teachers, dispatching Japanese students abroad to study science and research, and establishing schools for the teaching of courses in modern science and technology.

TWO FIELDS OF EDUCATION CONDUCTIVE TO TECHNOLOGICAL GROWTH

Engineering and social education promoted Japan's technological growth: engineering during the Meiji and social education during the Taisho (1912-1926) and Showa (1926 -) periods. Apparently, it is easier to see the relationship between engineering and technological growth because engineering is known to provide the technical know-how for technology transfer and development. On the other hand, it appears difficult to relate social education with the entry of foreign technology. Yet, the Japanese experience shows that with social education, a country can develop the discipline and virtue to adapt to the social changes brought about by industrialization and technological growth. The writer believes that through social education, the Japanese were able to welcome the entry of foreign technology. Thus, a discussion of social education and its relation to Japanese daily life during the period of technological modernization is deemed necessary.

Engineering. As mentioned earlier, the Japanese used two methods of training scientists and engineers in the Meiji. One was sending students abroad; the second was employing foreign teachers in the universities. In the first seven years of the Meiji (1868-1874), more than 500 students went abroad, with the number peaking in 1871. The United States, which attracted the greatest number of engineering majors, was the most popular country, followed by the United Kingdom, Germany, and France. The United Kingdom was said to be advanced in the fields of mechanics, commercial law, geology and mineralogy, iron-making, architecture, and shipbuilding. In Germany, fields such as politics, economy, physics, astronomy, geology and mineralogy, biology, medicine, and pharmacology were popular.

Figure 2 shows that engineering majors were the most numerous throughout the Meiji. Records also show that, after returning home, engineering majors found employment across a wide range of professions. In the first decade of the Meiji, the majority went into the public sector. The navy attracted almost a quarter of students (24 per cent); others worked in railroads (15 per cent); in the ministries of public works, agriculture and commerce, education, home affairs, Kaitakushi or Bureau for Land Development in the Hokkaido area (12 per cent); in mining (nine per cent); and in shipbuilding (nine per cent). The navy attracted students who had specialized in mechanical engineering and shipbuilding. Most civil engineering majors went into railroad construction and in the national or local government service, and some worked for the navy on various construction jobs.

Figure 2 shows the approximate trend of Japanese students who went abroad and studied in their respective specializations. Students who took up engineering were more numerous than those who studied physics, mathematics, and chemistry. When they came back to Japan, they imparted their acquired knowledge and skills using the Japanese language. The only way by which they could share with their countrymen the technology that they learned from the West was through Nippongo.

The employment of foreign teachers and advisers was adopted as another measure to train engineers and scientists. The two major areas of employment were in teaching and engineering: in the public sector by the 1880s, the foreign engineers had been overtaken by the teachers in number, whereas in the private sector, the engineers had the lead until the 1890s.

As regards the relative proportion of foreign employees in the private sector, there were more British than French employees in the navy, whereas the French were overwhelmingly dominant in the army. The Americans topped in the Ministry of Foreign Affairs, while the Germans and British were dominant in the Ministry of Home Affairs. The British also dominated in the Ministry of Public Works, particularly the Department of Railroads. The Japanese railroad system was initiated under British supervision.

After 1878, or the 11th year of the Meiji, the percentage of foreigners among the total number of employees in the various departments of the Ministry of Construction dropped dramatically—from 527 in 1875 to 321 in 1878. In the case of engineering, the number fell from 205 in 1875 to 118 in 1878. By 1880, the number of engineers as well as teachers had fallen to half in contrast to its peak in 1874. This reflects the reality that the Japanese had taken over the jobs that the foreigners used to occupy. Such “japanization” in the areas of engineering was inevitable, not only because the government experienced financial difficulties in paying the foreigners’ high salaries, but also because Japanese scientists and engineers had gained enough experience in handling jobs in which the foreigners had been engaged.

Social Education. The Japanese did not only establish a formal education system to catch up with the West. To enable their society to adapt to the rapid expansion of the economy and technology, especially to the age of information technology in the 1950s, they also popularized education outside the schools.² The Japanese government made a comprehensive plan for popular education. From 1918 onward, it greatly encouraged popular education that, in turn, prepared the

way for progress in the field of social education. Social education consisted of civic courses for government schools and other appropriate institutions in all prefectures and major cities. Courses for laborers, farmers, fishermen, and merchants were instituted, and home education encouraged.

Many youth groups for boys and girls were also organized. The Youth School Order was promulgated on April 1, 1935, to establish the system of youth schools and integrate youth training centers and vocational supplementary schools. The Ministry of Education, with the cooperation of the Ministry of Army, stressed physical and mental discipline and virtue as well as vocational studies and the knowledge and skills necessary for everyday life.³ It also emphasized the development of patriotism among the youth, who were asked to help in producing supplies for Japan's war with China up to the end of the Second World War.⁴

Social education also played a critical role in the postwar Japanese society. The development of the administration and the content of social education during the postwar period were more relevant to the Japanese society than the changes in other educational fields (Nagai 1971, 298).⁵ The reason was that postwar Japan underwent various social phenomena such as increased economic opportunities in the cities, nuclear families, concentration of the younger generation in highly urbanized areas thus profoundly changing both village and city life, increased percentage of the population enrolled in the upper secondary schools and universities thus upgrading the educational level of the population, large proportion of middle-aged and old persons in the population, and expansion of leisure time.⁶

Given the far-reaching nature of such social changes, social education had to revise and enlarge its contents and methods so as to adapt to the needs of the various age groups and their lifestyles. The revision consisted of making it obligatory for cities, towns, and villages to appoint social education supervisors, spending public funds for private organizations devoted to social education activities, establishing an official standard for citizens' public halls or community centers, and encouraging additional services from social education committee members.⁷

Other developments included the establishment of youth centers in 1959 and the opening of nature centers for children in 1970—all designed to promote the sound development of boys and girls in the urban areas. The Japanese believed that group living amidst natural surroundings was a means of cultivating the spirit and the attitudes of discipline and service.⁸

All discussion about social education implies that the Japanese from the early 1900s to the postwar years were indeed eager to adapt their society to the changing demands resulting from industrialization and technological advancement. They realized not only the importance of a formal education system but also the significance of social education in their everyday life. Without the flexible combination of the two systems, they could not have successfully attained economic growth and assimilated foreign technology.

THE JAPANESE LANGUAGE: A CONCRETE EXAMPLE OF ADAPTABILITY

China had a great influence on Japan. Some of the most remarkable cultural elements that Japan got from China and which had a tremendous impact on Japanese adaptability were the Chinese writing system and abstract ideas like virtue, loyalty, filial piety, duty, moral obligation,

manners, bravery, reason, philosophy, nature, and feeling. The adoption of many abstract nouns was a wise decision, for it went a long way in enhancing the cultural level of Japan. It also helped a great deal when European culture was introduced in Japan and the Japanese had to coin words that would correspond to Western ideas. For example, Japan was able to translate the names of diseases in European languages when modern medicine was introduced from the West because she already had the equivalents of the terms in Chinese.

The fact that foreign words got into the Japanese language implies two things: first, that the Japanese people admire and value anything foreign and adapt it to their own culture; and second, that the Japanese have a passion for anything new and foreign. The nature of their language was such that it was easy for foreign words to be assimilated. It proved convenient for Japanese culture to take in whatever was good in foreign culture.

The language reform movement that was born during the Meiji, or Gembun'itchi, serves as proof of the government's realization of the significance of developing a standard language, whose important function was to expedite the flow of information necessary for social change. The government focused on education and the press as the two major areas in which the language issue emerged as important. A group called Enlightenment scholars sprang up and dedicated themselves to the dissemination of the knowledge and ideas they considered essential for Japan's survival. Some of those concerned with education in all its forms and the printed media soon realized the hindrance which the old written Japanese posed to the accelerated spread of information. Fukuzawa Yukichi, one of the outstanding journalists of the Meiji, together with other intellectuals and the former samurais-turned-bureaucrats who advocated language reform, became convinced that if the modernization of Japan were to be attained, the classical style should be replaced with a written style that was understandable to the masses. Even as early as in the second half of the Tokugawa period, several Japanese scholars of the West already realized the value of the colloquial style (meaning oral, as used by a large group of speakers). The scholars noticed the relationship between the colloquial style of European languages and the development of Western learning, and thought of applying the colloquial style for Western learning to the Japanese language. For example, Ōtsuki Gentaku remarked that the colloquial style he observed in Dutch books had the twin virtues of allowing detailed recording of facts and being easy to understand.⁹ Ōba Sessai postulated that the colloquial style of European languages facilitated the development of Western learning.¹⁰

The arrangement that Japan would give priority to only three languages (English, French, and German) started during the Meiji. The Meiji leaders opted to concentrate on these languages to avoid dissipating their country's limited capabilities. Simultaneous with this concentration was Japan's striving to import and assimilate the knowledge, advanced scholarship, and superior technology available in the industrially advanced Western nations. It was believed that such knowledge was essential for the urgent task of converting Japan from a poor, weak, and underdeveloped nation into a modern and industrialized country. Thus, the pattern of translating foreign works and materials into Japanese was wholly for the purpose of importing information.¹¹

Given the shortage of economic resources, the language study policy adopted by the Meiji leaders was a sagacious one.

The katakanization (transliteration of foreign words into the Japanese square syllabary) of not only scientific but also other loanwords constitutes the adaptive mechanism of the Japanese language in importing technology. Aside from the kanji, which can provide the exact Japanese equivalent of a foreign word, the katakana provides a medium for transliteration. Because the Japanese language has a large number of homonyms, it is often difficult for Japanese scientists to get their points across through the ideograms. Because they find it difficult to refer to what they mean using the Japanese equivalent in speech or lecture, they stick to the original foreign vocabulary when they converse. However, both the kanji and the kana (hiragana and katakana) system have facilitated the permeation of not only scientific loanwords but also cultural loanword elements into spoken and written Japanese. This permeation of cultural loanword elements displays the unusual quality of Japanese culture—its “eager acceptance of things foreign combined with the defense of the traditional.”¹²

SHIPBUILDING

A vital field where the Japanese language demonstrated its adaptability was in the shipbuilding sector. In shipbuilding the Japanese have remarkably shown their great enthusiasm for technological assimilation. During the period of assimilation of Western shipbuilding technology before (1850-1867) and after (1867-1885) the Meiji Restoration, several technological circumstances that were indigenous to Japan as a latecomer to industrialization took place. One event was the translation of a Dutch textbook on steamships by a famous Rangaku scholar upon the order of the Satsuma han (fief in southwestern Japan) in the 1850s.¹³ After the lord of the Satsuma han ordered the translation of the Dutch book, he gathered skilled craftsmen to construct a steamship model based on the translation. It may be noted at this point that the tradition of Rangaku, which occurred during Japan’s isolation from the world, became the basis not only for the construction of the Japanese steamboat in March of 1858, but also the development of cannon casting and creation of other scientific apparatuses.¹⁴

Another circumstance that facilitated Japan’s assimilation of the steamship technology was the technology transfer from Holland, after which the Bakufu or feudal Japan’s central government established the Nagasaki Iron Works in 1857. Together with that establishment was the provision of technical assistance by Holland and the creation of a naval academy. Consequently, the Bakufu began to construct ships in the Nagasaki Iron Works and modernized the Ishikawajima Shipyard with imported machinery.¹⁵ Apparently, the Bakufu turned to mechanical engineering because the output from the translation of Dutch books was not enough in building the naval power of the government against the West.

The Japanese experience in the introduction of steamship technology again illustrates the openness of the Japanese in assimilating ideas. The informal networks of practical knowledge greatly facilitated the spread of that technology.¹⁶ A measure of the successful introduction of

steamship technology in Japan was the completion, without any foreign assistance, of the Chiyodagata-maru, a 136-ton warship built at the Ishikawajima Shipyard in Mito in 1866.¹⁷

CHEMICAL INDUSTRY

One of the modern sciences that developed in the Meiji, but had its foundation in the late Edo years, was chemistry. The study and practice of chemistry which is both a basic subject that aided technological development and a concrete exemplification of Japanese adaptability, began to take root in the remaining years of the Edo era.

In 1864, the Institute for Chemical and Physical Research Experimentation (Bunseki Kyūrijo) was established. After the Meiji Restoration, the institute was merged with a hospital and medical research center to form the Seitokukan, an institute under the control of the prefectural government of Nagasaki.

The chemical industry in the 1870s exhibited the government's emphasis on information awareness through its invitation to foreign engineering firms and technicians, book learning, the studies abroad of army and navy officers and, most surprisingly, translation of technical terms.¹⁸ Appendix 1 compares technological development and diffusion in the electrical and chemical industries of various countries in the 1870s. In contrast to Britain, United States, and Germany, Japan was the only country that utilized the translation of foreign technical concepts and vocabulary as one of its strategies in disseminating information.¹⁹

The chemical industry also demonstrated the successful combination of the roles of government and various research institutes and universities. The Nitrogen Research Institute, for example, carried out basic research based on German patents in such areas as ammonia synthesis and production of nitric acid, hydrogen, and methanol. In developing imperial universities, the government created chairs for research in applied chemistry. The Tokyo Imperial University had chairs in such areas as acid, alkali and fertilizer, dyestuff, and coal chemistry; fiber and cellulose chemistry; plastic and petroleum chemistry; and photochemistry.

Some words in chemistry in Table 2 indicate the ability of Nihongo to transliterate foreign terms. The table shows that Nihongo has the capability to translate a chemical term or terms for chemical solutions in various ways: in katakana, in a combination of katakana and kanji, or in a mixture of katakana and furigana.^{20 21} Such inherent capability shows that the Japanese language is very flexible and open to the transfer of technical terms.

CONCLUSION

The article claims that adaptability in the Japanese culture, particularly in language, facilitated the adoption and diffusion of foreign technology. Although cultural adaptability is not sufficient, it is necessary to technological development. While the absorptive capacity for technology varies from country to country, Japan has a language that effectively served as tool for the transfer of technology. Technology, once created, is available to everyone as a public good. Japan is an example of a country that was able to take advantage of technology. The lack of

natural resources drove Japan to industrialize. The great need for natural resources (arable lands, for example) prompted the people to attempt to maximize what they have. They developed machinery to increase efficiency and productivity on farms.

The Japanese exhibited the adaptability of their culture in various fields and in various ways—Japan’s educational system and social education, shipbuilding, chemical industry, medicine, engineering, and ultimately their economic take-off. In short, cultural adaptability contributed to Japanese “civilization and enlightenment.” The root of Japan’s postwar technological development in some sectors can be traced to a combination of two or more factors such as the Meiji’s educational system, indigenous or traditional technology, and the adaptability of the Japanese language itself. Japan’s public educational system which is based on continental European models, produced not only a literate work force but also a versatile pool of skilled technicians. It culminated in a number of imperial universities, which at that time ranked with the best institutions of higher learning in the world.

Japan’s technological growth was also boosted by the desire of the Japanese to simplify their language during the Meiji, as well as by the large-scale translation movement that transpired before the Meiji Restoration and influenced Japan’s feudal lords to assimilate technology from the Dutch. The development of the shipbuilding industry began with a Rangaku scholar’s translation of a Dutch book on steamship technology. Japan became a competitive producer of ships in the post-Meiji years as well as in the early 1950s.

The ability of the Japanese language to transliterate foreign words and allow cultural loanword elements to permeate the structure of the language indicates another facet of Japanese adaptability. By allowing the entry of foreign loanwords into their language, the Japanese showed the openness of their culture and society in general. This openness was the impetus for further economic development that went beyond the Meiji era and culminated in the so-called Japanese miracle of the postwar years.

Contrary to the general view, this article argues that Japanese culture is very adaptable. While we can think of other subtle manifestations of this particular characteristic, it is sufficient to mention only the most obvious ones. Without adaptability, Japan could not have fostered innovation and technological development even before modern times. If, in the past, the Japanese seemed highly resistant to change, as the common notion tells us, it was because they believed that such a change would not be beneficial. The fact is that the Japanese readily embraced change when they saw that it would lead to something useful to their society. While maintaining their originality, they did not hesitate to accept change. This kind of adaptability has defined the *Japaneseness* of the Japanese and their openness to changes in many aspects of their society and life in general. It is this kind of adaptability, as the article repeatedly point outs, that defines their culture as a whole.

However, one must be aware of the limitation of using culture as an explanatory variable for technology transfer. Meiji Japan’s experience of technological growth through foreign technology undoubtedly involved other factors aside from cultural adaptability. Culture was not the only variable that accounted for the favorable entry of foreign technology to Japan during the

Meiji. But had culture been absent or lacking, Japan could not have founded a technological base necessary for the successful adaptation of foreign technology. Japan could have gone the way of the Ottomans who, after accepting foreign technology through translations and purchase, did not indigenize and innovate for long-term use. If that were so, Japan would have been just an economically mediocre nation.

ENDNOTES

¹ Ministry of Education, Science and Culture (MESC), Minister's Secretariat, Research and Statistics Division. Japan's Modern Educational System: A History of the First Hundred Years (Tokyo: Division, 1980), 22.

² Michio Nagai, "Westernization and Japanization: The Early Meiji Transformation of Education," in Donald Shively, ed., Tradition and Modernization in Japanese Culture (New Jersey: Princeton University Press, 1971), 185-186.

³ Ibid., 188.

⁴ Ibid., 202.

⁵ Ibid., 298.

⁶ Ibid.

⁷ Ibid.

⁸ Ibid., 300.

⁹ Nanette Twine, Language and the Modern State: The Reform of the Written Japanese (London: Routledge Press, 1991), 78.

¹⁰ Ibid.

¹¹ S. Takao, "The Case of Spreading the Japanese Language," Japan Echo 19, no. 4 (1992), 81.

¹² The phrase comes from Shuji Hayashi's article, "Culture: The Invisible Barrier," in Culture and Management in Japan (Tokyo: University of Tokyo Press, 1988), 52.

¹³ Tetsuro Nakaoka, "From Shipbuilding to Automobile Manufacturing."

¹⁴ Tetsuro Nakaoka, "The European Industrial Economy and the Endogenous Development in Asia."

¹⁵ T. Nakaoka, "From Shipbuilding to Automobile Manufacturing," 37-66.

¹⁶ Roger Greatrex, "Comparative Perspectives upon the Introduction of Western Steamship Technology to Japan and China," Senri Ethnological Studies 45 (1998), 121.

¹⁷ *Ibid.*, 114.

¹⁸ Charles McMillan, The Japanese Industrial System (Berlin: Walter de Gruyter, 1985), 97.

¹⁹ The ability to translate technical terms is a characteristic of the Japanese language's adaptability. The appendix was used to emphasize that ability in developing Japan's technology in the chemical industry.

²⁰ Furigana is the kana system of writing that transliterates a Chinese character into hiragana or cursive style of Japanese writing.

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