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Skills and Technological Development in the Early Stage of Industrialization – Implications from Japanese Experiences in the Meiji Era

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Abstract

Japan embarked on its major efforts to industrialize during the later part of the 19th century, the Meiji era. This article examines the process of acquiring and internalizing advanced technology and developing Japan's human resources during that period by applying a model developed by the author. This model analyzes the challenges developing countries currently face with respect to skills development: namely, bridging the three gaps of policy, relevance, and finance of publicly provided skills development. Via a case study of the iron and steel industry, the article describes: how the government made a strategic choice with respect to technology; how the government played the dual roles of direct management of the industry as well as stimulating the growth of private industry; the extent to which the government made conscious efforts to use the existing socio-economic system related to the industry; and how it used local resources without depending on foreign loans. The government initially depended on foreign experts, gradually replacing them with domestic experts who were initially trained abroad but later at home, followed by development of middle-level skilled workers. The article concludes that many of the factors that were key to the success of the countries that grew out of underdevelopment over the last half century were present in the policies and approaches adapted by Japan during the Meiji era.

Introduction

Most of the previous studies on Japanese experiences of industrialization were conducted with a view to find lessons that are directly applicable to developing countries today. This approach often falls short of providing relevant lessons because of differences in important contextual factors. To avoid this problem, this paper starts by examining key characteristics of challenges surrounding skills development of developing countries. Based on this, an analytical framework is constructed. The paper then reviews means and processes of acquiring the advanced technologies from the West and internalizing them, using as a case study the iron and steel industry in the Meiji Era. Using the analytical framework built based on the challenges of today's developing countries, Japanese experiences will be re-assessed and conclusions will be drawn, while recognizing important contextual differences.

Three Gaps of Developing Countries

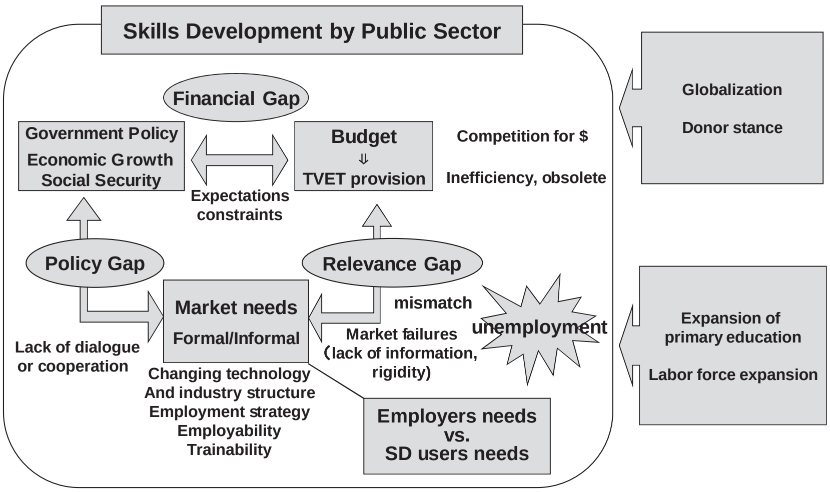
This section presents the challenges in skills development that developing countries face today. Governments of such countries are more than ever eager to enhance levels of skills of their labor force. Both domestic and international factors are driving the countries toward skills development.

In coping with high expectations and pressures to develop the skills of their labor force, developing countries face several challenges. The labor force is expanding every year. In Sub-Saharan Africa, it has increased from 195 million in 1990 to 338 million in 2008, including those unemployed (World Bank databank). Other regions have also seen an increase. Past high fertility, educational expansion and increased participation of women in economic activities explain this trend, potentially a positive sign for further economic development. However, if the labor market fails to expand enough as to absorb net new entrants, or if skills of workers do not match needs of the industry, unemployment can rise. In the formal sector of low-income economies, absorptive capacity in the public sector is already saturated, and the job openings in the private sector is not increasing in pace with the growth of the labor force. Youth unemployment already poses serious concerns in many developing countries. Lack of reliable and timely information system concerning the labor market adds to the rigidity of the market. Losses of gains in skills development due to HIV/AIDS are also serious in many Sub-Saharan African countries. Another implication of the expanded labor force is the expansion of the informal sector on which I will touch upon later. Often, small firms are financially and technically not capable of providing in-firm skills development systematically in the way large-scale firms can do (Gill, et al., 2000).

On the supply side, providers, contents, and program durations of Technical and Vocational Education and Training (TVET) are all diverse. Looking only at the public sector, usually many bodies of different ministries (Education, Labor, Industry) and local governments are involved in regulation or in direct provision. Adding the presence of the private and informal sector, it is far from an easy task to just grasp the entire situations of TVET. The share of TVET in total secondary enrolment varies significantly especially at the upper secondary level, ranging from high countries of Argentine (90%) and Uzbekistan (81%) to low countries like Kenya (2%), India (2%), and Saudi Arabia (1%) (figures for 2008, UIS 2010). Other countries have shown a remarkable growth in secondary TVET enrolments – between 2000 and 2005, it increased by 33 times in Ethiopia, 8 times in Senegal, and 5 times in Ghana (World Bank databank). Variation of the level of TVET activities cannot always be associated with the levels of education expansion or economic growth. One needs to observe carefully to see what actually determines the nature of TVET in a particular country.

Public sector TVET typically faces three gaps. The first is a <u>policy gap</u>. As we have seen, the multiplicity of players make grasping the comprehensive picture of skills development programs provided by them difficult and the building of reliable information system is lagging behind. Still, policy makers and curriculum developers seldom talk with the business community, specially the informal and small and medium size firms which usually represent the overwhelming majority of total employment. This results in policies that do not appropriately reflect the real situations of the labor market or the industry's needs. Building trust between the government and the business community becomes even more difficult.

The second is a relevance gap. Contents of skills development do not meet labor market needs or the skills requirement of the industry. There are several aspects to this problem. Obsolete curriculum or a curriculum that, although well-intended, fails to be responsive to the reality on the ground; old equipment and technology that are no longer used in the workplace so the acquired skills are not useful. TVET providers usually intend to equip their trainees with knowledge and skills that are immediately applicable upon employment, but employers often favor human resources that are capable of responding flexibly to changing needs and new technology to those with very specialized skills in one specific area. Moreover, TVET programs are often not the first choice of many trainees who enroll because of lack of other options and who aspire to acquire higher skills that will lead to higher incomes; not only do the actual TVET programs not allow them to do so, but the labor market may prefer low-cost low skilled labor. Overall, the risk is fairly high that the intention, process and results of TVET are not reflecting the real needs on the ground. In addition, if most of the employment opportunities lie in the informal sector, in other words, if the conditions for the formal sector to generate sufficient job opportunities are not present, it becomes difficult to justify more investment in TVET that primarily aims at employment in the formal sector.



Source: Yoshida 2007

Figure 1. Three Gaps with the Public Sector Skills Development

The third is a financial gap. EFA requires stronger financial commitment of the government for the universalization and quality improvement of primary education, which comes at a time when pressure mounts to expand secondary and even tertiary education. Even if the government of developing countries has a strong interest in skills development, severe budgegtary constraints make it very difficult to allocate more resources to TVET in the public or private sector. Typically, the cost of providing TVET at the secondary level is more than double of regular academic programs (Gill, et al., 2000). If the providers intend to provide skills training that are relevant, they need to invest continuously in equipment, as the needs of the labor market faces constant changes and progresses. This represents a heavy financial burden. Therefore, despite the increasing needs for skills development and the policy intention to strengthen the capacity to respond to this need, it is not only difficult financially to do so but simply expanding supply could be very risky, because the likelihood of not being able to respond effectively to labor market demands remains high. Introducing user fees, diversification of the sources of finance, relying more on the roles of the private sector, shifting the public sector's roles from direct provision to more of a facilitator and regulator, these are likely to be essential elements of any reform aiming at addressing current issues in the labor market for TVET skills. However, these types of comprehensive reforms are not always part of current reform packages.

In many cases, small and medium-scale firms need a set of public support measures to help correct market failures such as inaccessibility to credit/finance or to new technology. They also expect the labor market to function more effectively. If these elements are absent, investment in skills development will not bring much return. For expansion and strengthening of education and skills development to realize higher productivity, firms and workers and their actual roles need to be commensurate. This is a most difficult task for developing countries under current circumstances.

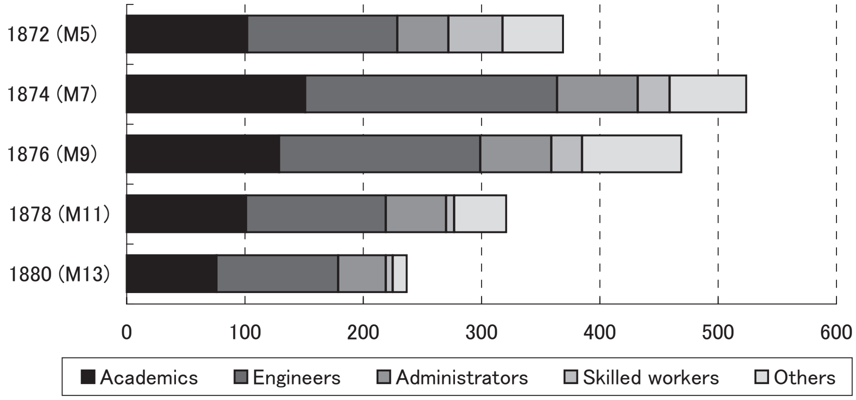
Acquisition of Western Modern Technology in Meiji Japan

Modernization, industrialization, and Westernization characterized Japan's development process during the Meiji era. These were perceived to be largely overlapping. On the political scene, a series of events followed after the Meiji Restoration that handed over the sovereign authority to the Emperor in 1868 (M1, the first year of the Meiji era): abolishment of fiefs replaced by prefectures in 1871, land and taxation reform in 1873, the promulgation of the Imperial Constitution in 1889, and the inauguration of the Imperial Parliament in 1890, thus forming the foundation of the modern democratic systems. Meanwhile the social class system was abolished in 1873. The Meiji government undertook the top-down industrialization policies to catch up with the Western powers, under the two slogans of "Enriching the Nation and Strengthen the Military (*Fukoku Kyohei*)" along with "Industrial Development (*Shokusan Kogyo*)".

Tohata raises four major roles of the public sector for the Meiji industrialization (Tohata 1964:41-59). First, provision of capital to finance industrialization which was done by mobilizing savings into the capital market through encouraging the establishment of private banks and by issuing bonds and borrowing. Second, acquisition of modern technology initially by hiring experts. Third, dual roles of the government both as a direct implementer of industrialization and as a facilitator of private enterprises. Fourth, human resources development. He adds that trading functions of importing modern industrial equipment and exporting Japanese commodities to pay for imports were mostly handled by foreigners (90 percent of trade in 1887).

Our primary interest lies in how Japan acquired modern technology from the West and developed domestic skills. These were pursued by employing Western experts with imported Western plants and equipments, by sending students to study abroad who gradually replaced the employed Westerners, and by building education and training facilities, beginning with the higher level of education and later at lower levels.

Hiring Foreign Experts: Hiring Western experts was one of the major means of transplanting and acquiring their advanced technology in the state-run factories. The model was already implemented in the pre-Meiji era for the Yokosuka Shipyard built by the Tokugawa Shogunate, and the Kagoshima Spinning Mill by the Satsuma fief among other occasions during 1850s and 60s. All the plant and equipment were imported, and engineers and skilled workers for major functions were hired from abroad, de facto depending on them for the plant management (Uchida 1986:173). It is reported that over 500 foreign experts were hired by the government at the peak in 1875, from the UK, France, Germany and the US (Odaka 2007:4). They were mostly for the fields of engineering and academics (Figure 2). In the case of the Ministry of Industry (Kobusho) that took a central role in transplanting modern technology, foreign experts were employed extensively for railroads, mining, and mechanical engineering. Noteworthy is the case of the bureau of railroad that hired as many as 253 foreigners ranging from superintendent at the top to engineers, engine drivers, and repair shop mechanics (Nakaoka 2006:58-59). They were paid with extremely high salary, summing up to account for some 40 percent of the current budget of Kobusho during the 1870s, and over 10 percent in the case of the Ministry of Education (Monbusho). In some individual cases the salaries were much higher than that of the then prime minister (Emi1962:795, Ohno 2006:62).



Source: By author using data from Tohata (1964:54).

Figure 2. Composition of Foreigners Hired by the Government in the Early Meiji Period

In 1879 (M12), the government took a position of replacing the foreign experts with Japanese engineers, and the number of foreigners decreased. This was accelerated during the1880s under the austere budget promoted by Finance Minister Matsukata. The government decided to privatize state-run enterprises, except for those that should remain in the public sector. Thus, 14 public enterprises which had served as models for nurturing private enterprises were privatized to start with (Nakaoka 2006:72, Uchida 1986:190). After the privatization, the remaining foreigners and absorbed modern technologies were transferred to the private sector. The trend of reducing foreign experts was reversed again in the face of industrial boom later in the Meiji period.

Study Abroad: In the end of Edo period, the Shogunate government and powerful fiefs were sending promising youth to advanced countries in order to acquire modern technologies and Western knowledge. While their main purpose focused on the naval enforcement, they studied mechanical engineering, shipbuilding, steam engine among others, and became central promoters as policy planners or practical leaders during the Meiji era (Uchida 1986:171-2).

During the first 5 years of the Meiji period, 500 students went to study in the US alone. As of 1873, 250 government-sponsored students and 123 self-financed students were studying abroad. In 1875 (M8), Monbusho streamlined and strengthened the selection control of the outgoing students, sending 11 and 10 students in 1875 and 1876 respectively. Thereafter, the number of students sent by Monbusho stayed at less than 10 annually until 1894, but afterwards increased to an average of above 30 per year for the rest of Meiji period, totaling 661. The students were mainly sent to the US, the UK, France and Germany in areas of laws, economics, physics, chemistry and engineering

(Monbusho 1981, Table 30). It is certainly probable that a much larger number of youth went abroad when privately-funded students are included.

Human Resources Development in Engineering: In 1870 (M3) Kobusho (Ministry of Industry) was established to take charge of promoting industrialization. Kobusho opened a school of engineering called Kogakuryo in 1871 which was upgraded two years later into the College of Engineering (Kobu Daigakko) for pre-service training of senior engineers for the public sector. A Scottish engineer, Henry Dyer, was invited as a founding principal who served during the period 1873-82. The college comprised preparatory general education, specialized courses, followed by field-based practical courses each lasting two years. Eight departments were opened for civil works, machinery, architecture, telegraphic communication, chemistry, metallurgy, mining and shipbuilding. A half of the last two years was dedicated to field practices (Uchida 1986: 174, 187). Eleven of the first batch of graduates continued to study in the UK, and returned to replace the foreign experts being employed by the government. When Kobusho was abolished in 1885, the College was transferred to Monbusho, and formed the engineering department of the Imperial University after being merged with the polytechnic department of Tokyo University. With this reorganization, it became more theory oriented with less emphasis on practice (Nakaoka 2006:443). The College produced over 200 graduates in 10 years who were conferred a high status as engineering technologist and formed a prestigious profession, enhancing the image of engineers (Iwauchi 1989:7). They were recruited as replacements of the expatriates and many of them were transferred to the private sector when the state-run factories were privatized.

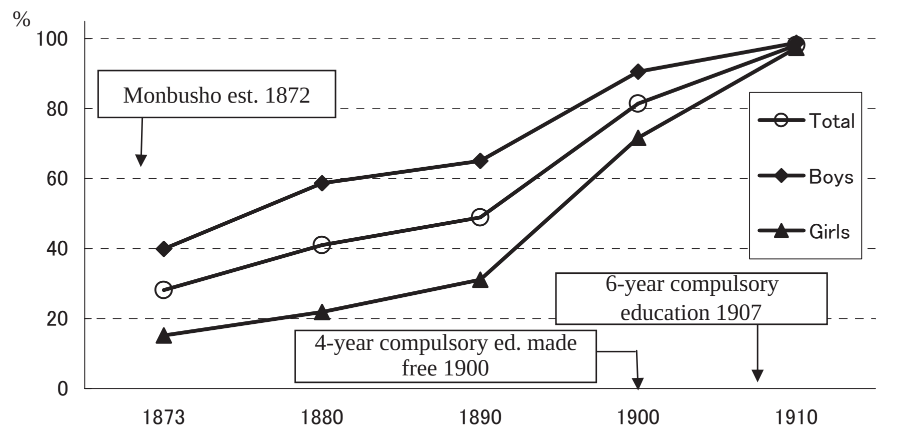
Similar training schools were established for shipbuilding, tele-communication, lighthouse and other specific fields. Graduates from the railroad engineering training school successfully constructed a new line of railroad by 1880 led by the returnees from overseas study, without support from foreign experts (Nakaoka 2006: 436).

As mentioned below, Monbusho gave priority to primary education as well as higher education. This left a gap in raising the middle-level workforce in the modern industry. Certain experimental efforts were made to develop technical education institutions at the secondary level in the early time of the Meiji period which were subsequently suspended. The exception was the Tokyo Craftsman School (Tokyo Shokko Gakkou) established in 1881. It comprised the four disciplines of machinery, applied science, dyeing and weaving, and pottery, and was expected to take on roles of training middle-level engineers for the modern industry and leaders to modernize the light industry. While most of the graduates from the College of Engineering took positions in the public sector, more than a half of the graduates from this school were employed in the private sector.

Because of insufficient supply of training facilities, technicians (Koshu) to support engineers were in short supply in the workplace. To fill this shortage, a technician school was established in 1888 with financial support from the private sector. It was not regarded as a formal technical school, but successfully produced human resources more quickly in one and a half years to meet the industrial needs in the areas of civil engineering, machinery, electrical engineering, architecture, ship-building, metallurgy, mining and manufacturing chemistry (Amano 1997:155). Similar undertakings were made by the private sector, such as the Iwakura Railroad School, the Mitsubishi Industrial School, the Kansai School of Commerce, and the Tokyo School of Commerce and Industry.

It was only during the latter half of the Meiji era, when the industrial education system was formally established. This was in ex-post response to the increased demand for skilled labor when the Japanese industry made a remarkable progress after the two wars (Sino-Japanese during 1894-95 and Russo-Japanese during 1904-05).

A School System by Ministry of Education (Monbusho): Monbusho was established in 1872 (M5), and the School Act (Gakusei) was proclaimed in 1873 which opened the educational opportunities for the entire nation. Primary education was particularly emphasized. At the start, the enrolment rate was rather low at 39.9% for boys and 15.1% for girls (and 28.1% on average) in 1873 when tuition fees were charged. Initially the period of more than 4 months per year and for the duration of 4 years was compulsory education, which was expanded to the full 4 years in 1900 when the fees were abolished, and in 1907 the compulsory education was extended to 6 years. The enrolment rate exceeded 90% by then for both boys and girls (Figure 3). During the Meiji period while the industrial modernization was pursued, human resources development became an urgent issue. But the Monbusho considered universalization of general primary education and training leaders at the university as their priority. Vocational or industrial education (the term used in Japan) was provided by related ministries and was put into the formal structure of education some decades later in the second half of the Meiji period.



Source: By author based on Monbusho (1962) Annex Table 3.

Figure 3. Enrolment Ratio of Japan's Compulsory Education

It was only in the 1890s under the committed Minister Inoue that Monbusho enacted the Supplementary Vocational School Act (1893) and the Apprenticeship School Act (1894). He also initiated the Law of the Central Financial Support for Vocational Education (1894). The Vocational School Act of 1899 and the Specialized School Act of 1903 together provided the platform for the formal industrial education at the secondary level and helped to sharply boost the number of supplementary technical schools and apprenticeship schools.

Apprenticeship schools: The apprenticeship schools targeted the primary school graduates aged 12 years or older and provided education and training to become skilled workers in 6 months to 4 years. The intention behind this was to transform the traditional inefficient apprenticeship by bringing it into the formal education system, thereby generating basic-level skilled workers who were highly needed by the industrialization. The establishment of this type of schools was eased by allowing them to be attached to primary schools, which helped the rapid growth in their number – from 4 in 1894 to more than one hundred in 1910. The apprenticeship schools offered woodwork, lacquer ware, and pottery courses for the traditional industry, and they helped modernize technologies used in these areas. The number of apprenticeship schools further increased during the economic expansion in the late Meiji period and thereafter in response to the modernization of industry under the import substitution and the heavy industrialization, covering the fields beyond the traditional industry. The apprenticeship school as a part of the school system was abolished in 1920, when some of them were promoted in status as technical schools while others were closed.

Supplementary Vocational Schools: The original intention of supplementary vocational schools was to assist the expansion of primary education by supplementing it and at the same time to prepare pupils for work by exposing them to introductory vocational education. When the enrolment rate of primary education rapidly rose from 60% in 1894 to 94% in 1904, the schools shifted their roles to providing part-time (evening or seasonal) training and education for youth at work and expanded nationwide. The number of supplementary technical schools increased from 9 in 1895 to 294 in 1909. Despite the intention of the financial support by the central government to promote industrial education, it was rather agricultural supplementary schools that mushroomed from 54 in 1896 to 3,785 in 1906.

In this way, the industrial education in the formal education system was consolidated at first at the primary and post-primary levels through the supplementary vocational schools and apprenticeship schools. As primary education universalized, the supplementary vocational schools were re-classified at the lower secondary level and, together with technical schools, commercial schools and other vocational schools, formed part of the system of secondary level industrial education.

In-firm training: In Japan, the firm-based training started in this period, largely due to the delay of the development of the industrial education system and to the peculiarity of the firms' needs for human resources. In the areas of heavy industry and mechanical engineering, in particular, traditional skills of the skilled workers became inadequate, and the apprenticeship training that prevailed needed to be strengthened by more organized education and training. The in-firm training in the first half of the Meiji era took both the formal and informal forms. This is exemplified by the Yokosuka Shipbuilder. Depending on the age at the time of recruitment, one would work as an apprentice for one to three years at the minimum wage while acquiring experience to become a skilled worker. In addition, the Shipbuilder had a more formal training facility which trained its employees into engineers and more skilled workers. Engineers were trained in a full-time course while the highly skilled workers were trained through a part-time course. The courses taught general subjects such as a foreign language, mathematics, geometry, physics, and chemistry, along with applied subjects such as sailboat building, ship-building, steam engine, etc. up to four years. The existence of such training opportunities had another role of retaining competent skilled workers who were highly mobile at that time and turn them into regular employees (Iwauchi 1989:39). During the second half of the Meiji period, more and more firms, but still mostly those of large scale, started to own their own training facilities.

Iron and Steel Industry in the Meiji Era.

This section reviews the process of acquiring modern industrial technology at the beginning of Japan's modernization, namely during the Meiji era (1868-1912), using as an example the case of the iron and steel industry. At that time, the iron-making technology of the advanced European nations was far ahead of Japan's traditional home-grown technology. The process followed will help understand how Japan managed to acquire and internalize within such a short period of time the latest technology that had developed in Europe during the span of some 400 years.

According to Nakaoka, the process of Japan's moderninzation of iron and steel-making can be divided it into three phases. The first phase is the shift from the traditional technology to the construction of reverberatory furnace and charcoal-fueled blast furnace in the 1850s. The second phase is the period of failure and success of establishing a coke-fired blast furnace at the Kamaishi Iron Mill during the 1880s. The third phase is symbolized by the state-run Yawata Steel Works that marks the establishment of an integrated system of pig iron and steel making process (Nakaoka 1986).

Preconditions: Prior to the arrival of the Western iron and steel making technology toward the end of the Edo period preceding Meiji, a traditional iron-making technology called *Tatara-fuki* was well established. It used a labor-efficient method of collecting iron sand, and balance-bellows replaced hand or foot-driven bellows as a wind blowing device.

This method was mainly practiced in the Chugoku region, a western part of Japan, that is endowed with quality iron sand with a low content of impurities.

In addition there was another iron-making method in the Nanbu fief, a part of the Tohoku (northeast) region using iron ore. The material in the region had a high iron content and produced superior reduced iron. Availability of a highly pure iron ore attracted the attention of Takato Oshima of the Nanbu fief who chose this area as a site for constructing a modern plant (Iida 1980:24).

First Phase: At the end of Edo period, the Tokugawa government had lost its controlling power, and influential fiefs such as Satsuma and Choshu had a strong voice in central government matters. Thus, each strong fief made innovative efforts. In the Saga fief, a reverberatory furnace was constructed in 1852 to found cannons for security purpose. It was only based on the Dutch textbook *The Casting Processes at the National Iron Cannon Foundry in Luik* written by Ulrich Huguenin (1826) without requiring any technical advice or support. The book was translated into Japanese in three different versions which were used to build the furnace of the same type in different parts of Japan. Founding cannons using the reverberatory furnace required a large quantity of pig iron of uniform quality. The existing traditional method of the *Tatara-fuki* furnace was not able to meet this demand. Oshima, who had joined the translation of Huguenin's textbook and had learned the modern technology, directed his attention to the local technology of smelting iron ore, and built a charcoal fired blast furnace in Kamaishi of the Nanbu fief in 1857. By the beginning of the Meiji era, 10 blast furnaces were built in total in the Kamaishi area, producing 3000 tons of pig iron per year which was used for casting coins as well as agricultural and daily tools.

Nakaoka points out that several pre-conditions were present in the Kamaishi area for absorbing advanced technology: the existence of an iron-making method of European origin using charcoal as a reducing agent; a large-scale privately managed smelting plant using iron employing over 1000 workers; availability of waterwheel-powered wind blower, and skills for furnace building and for producing fireproof brick (Nakaoka 1986:23-24).

Second Phase: After the Meiji Restoration, as one of a series of programs launched by the government under Shokusan Kogyo, the Industrial Development Policy, it was decided to build a massive scale integrated iron mill in Kamaishi. Oshima, who had joined and returned from a high-level Iwakura ambassadorial mission to the U.S. and Europe, was called upon to participate in this project. He proposed to build five blast furnaces each with a daily 5-ton capacity and horse-powered transportation of iron ore, in order to keep costs low and enhance the sustainability of operations. But the government adopted a plan advocated by a government-employed German engineer, Louis Bianchie, to build two blast furnaces with a daily capacity of 25 ton each, employing steam engine-powered transportation, including a converter plant to produce wrought iron, and a rolling mill.

Furnaces, railway and other necessary equipment were all imported from the UK. The mill started its operation in 1880, but had to stop after three months, and after 200 days of post-repair operation it was suspended again, and finally closed down in 1883. Shortage of charcoal as a reducer, excess capacity, and high costs of labor and transportation combined to make the mill unable to compete with imported steel (Iida 1980: 41-42, Nakaoka 1986: 26, Okada 1977). The government at that time was under severe financial stress and was unable to run further losses.

After the closure of the Kamaishi Iron Mill as a public enterprise, it was sold to Chobe Tanaka, a private entrepreneur. Tanaka followed the Oshima plan by re-starting with manageable smaller scale blast furnaces, and gradually expanded as workers developed operational skills. When the quality of pig iron thus produced was tested and proven to be competitive enough against the world –renowned brand Gregoreni pig iron from Italy, a stable sales route was opened with Osaka Arsenal, allowing to re-build operating capital. This was followed by a successful operation of the once abandoned large blast furnaces in 1895, after modifications of the design and improving charcoal efficiency and using coke obtained from local coal in Yubari, Hokkaido. The work was lead by Kageyoshi Noro, a leading domestic iron metallurgist who had studied theories and practices at London University and Freiberg University of Mining. This demonstrates the importance of the existence of engineering leaders who could critically assess the Western technology and adopt it to domestic conditions with good appreciation of the quality of local materials. The cost of producing pig iron at the Tanaka Iron Works was lower than that of the Yawata state-run steel mills. By this time, production of pig iron by blast furnaces had overtaken the traditional Tatara method, and the total production started to accelerate (Iida 1980:46-47).

Table 1. Pig Iron Production in Meiji Japan (ton)

	Tatara-fuki	Blast furnace	Total	Import
1874 (M7)	2,847	0	2,847	1,296
1882 (M15)	5,532	3,543	9,075	5,373
1887 (M20)	11,500	1,492	12,992	6,535
1894 (M27)	9,273	12,735	22,008	36,649
1902 (M35)	8,879	36,987	45,866	29,346

Source: Ohashi 1975:282, modified and corrected by author

The experience shows that the acquisition of external technology has two aspects – the *engineering capability* to design, build and operate equipment and plant, and the *social technological basis* that enables the society to absorb this technology, that is, the level of existing local technology, social relationship with the technology and related systems. Nakaoka argues that a leap may be possible in the narrowly defined aspect of technology in a small scale among a small number of individuals, but success is subject to the conditions of the social technological basis that influences the acceptability of the new technology. For the latter, a gradual change is possible but a huge jump is difficult (Nakaoka 1986:27).

Third Phase: State-Run Yawata Steel Works is a technological landmark in Japan that established an integrated system of producing pig iron and transforming it into steel. The integrated process begins with a blast furnace that melts and reduces iron ore into pig iron; then molten pig iron is oxidized and refined into molten steel in an open hearth, converter or electric furnace; and the steel ingot is rolled in a rolling mill into suitable shapes (Iida 1980:47-48).

The process resembled the Kamaishi case. Designed by F.W. Lührmann, a German blast furnace engineer, the whole plant including smelter, coke-fired blast furnace, a converter and open hearth furnaces, and a roller was imported from Germany, and some twenty German engineers and foremen were employed. Also, ten Japanese engineers were trained in Germany on the job in metallurgy, machinery and chemistry. German technology was preferred for its similarity of demand structure with that of Japan – smaller quantity with variety - rather than the mass production style found in the US. However, the quality of pig iron obtained from the first blast furnace in 1901 was inferior and coke efficiency was low, resulting in the suspension of the operation already in the subsequent year. Noro, who assumed the position of technical advisor, assessed the situations and attributed the failure to furnace design, low quality of coke, inappropriate blending of the charge, and poor knowledge of foreign engineers of Japanese raw materials. Subsequently, all the contracts with German experts except one were terminated, often prematurely before the operation was resumed in 1904. Continuous improvements were made thereafter with the blast furnace model and operational skills, resulting in significantly improved production efficiency. The steel produced by the plant accounted for over 80 percent of all the domestic production for the rest of Meiji era (Iida, *op. cit.*).

Labor force at the Yawata Steel Works was not skilled or experienced, mostly recruited among former farmers or workers at nearby coal mines (Iida 1981:21). It is understandable that smooth communication, building trust with foreign experts, and acquiring skills were not easy tasks for them. Human resources development within the industry was essential and the plant managers made efforts to upgrade skills of inexperienced workers and retaining the talented. Contracts with those with special skills were extended, long-term workers were commended, and provision of accommodation and welfare benefits were introduced. In addition, training facilities were established within the premise, both for the young workers and for retraining others. Here, an early model of life-time employment and company-based welfare system can be found.

Analysis

In the following, the Japanese experiences of the Meiji era industrialization will be examined in the framework of Three Gap model to see how the modern technology was transferred to Japan and internalized and how human resources were developed.

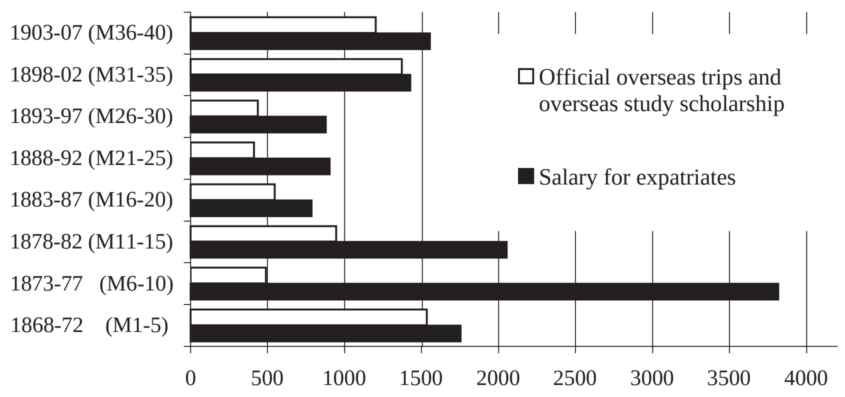
Policy: At the highest level of policy, the Meiji government invigorated the whole nation in the name of Industrial Development. The message was simple and clear, unifying all efforts toward the goal. Fields of industrialization were those in which the technological gap with the West were the greatest, known to be strategically important in order to strengthen the economic and military power, and those that would stimulate the existing major local technologies and industries. The government pursued this objective by playing the dual roles of direct implementation and facilitation. First, it imported plant and equipment from the advanced Western countries that embodied the modern technology. In the transition from transplanting to acquisition of the technology, the players changed from hired foreign experts to Japanese who had studied abroad. This was followed by building training and education capacity, initially at the higher level within the line ministry and later by the university under the education system. Much later, the education sector responded to develop a middle level workforce by building technical and vocational schools after elementary education had been mostly universalized. In the meantime, the shortage of skilled workers had to be filled within the industry by upgrading the skills of inexperienced workers through on-the-job training. Privatization of the state-run enterprises helped ease the otherwise huge initial investment costs, and stimulated the existing domestic technology. It should be noted that traditional technology co-existed for a fairly long time after the introduction of advanced technology, providing large employment opportunities. This is not to say that the whole sequence of actions was planned ahead; the bureaucracy was not necessarily staffed with experienced civil servants.

Relevance: According to Odaka, successful technological transfer requires a conducive socio-economic environment, an adequate technological level of the local economy, and a good match between the training provided and the needs of the recipients. The history of failures and successes of modernizing the iron and steel industry illustrates well this proposition. A premature and comprehensive introduction of the vast plant in one shot resulted in failure, aided by the lack of knowledge about the quality of local materials. If the technological gap is too large, a small number of individuals may be able to absorb the advanced technology, but a systematic application into practice will be undermined by the shortage of human resources who can follow, operate and own it. Noro asserted when directing the Yawata Steel Works that priority emphasis of internalization should be given to the steel making process which was at the core of upgrading the existing technology, instead of trying to upgrade technologies concerning the vast whole system at once. He added that at the same time related domestic industry such as machinery and construction should be strengthened. The success required cooperation with existing similar blast furnace plants, as well as co-existence with traditional *tatara* iron-making community (Iida

1981: 3-4). He was aware that it takes time for the new technology to settle in, and of the critical role of the traditional sector in bridging the gap.

Before the school-based vocational education mushroomed toward the end of Meiji era, on-the-job training was a common opportunity to disseminate acquired knowledge and skills. Graduates from technical schools established by the ministries were promised jobs with the same ministry. The mismatch between the training and the labor market demand, or the problem of unemployment of graduates, did not occur during this phase of the Meiji era. Private and local initiatives to train workers were also effective for the same reason. By the time Monbusho established vocational schools which rapidly increased in the latter part of the Meiji era, skilled workers were clearly in short supply. Where the labor market is functioning well and sending clear signal of demand, providing relevant training is not a difficult task.

Finance: It is not straightforward to assess whether the measures taken were cost-effective to fulfill the policy objectives and, especially, the need for technology acquisition and human resources development. Industrialization had to be achieved at any cost, after over 200 years of the closed-door isolation policy. Without this motivation, it would have been difficult to justify spending such a huge portion of the budget on hiring foreign experts and on equally expensive study abroad (Figure 4). The *de facto* monopoly of external trade by foreigners might have contributed to the ignorance of international prices. Nevertheless, domestic finance alone enabled the pace and scope of industrialization of the Meiji era without having to depend on foreign loans. Land and taxation reform, establishment of over 150 private banks and other finance policy measures contributed to it, together with the existence of the commercial sector and the private financial and entrepreneurial powers that complemented the process.



Source: Produced by author based on Emi (1962) Table 3.

Figure 4. Public Spending on Studying Abroad and Foreing Experts in Meiji Era (Unit 1000 current Yen)

Concluding Note

The Meiji era was one of the most dynamic periods in all aspects of Japan's social, political and economic development. This article has analyzed the effectiveness of skills development in terms of how successfully advanced modern technology was acquired and human resources were developed as an essential element of self-reliant internalization of the technology. The meaning of massive use of foreign experts, replacing them with Japanese experts trained abroad, the roles played by the Ministry of Industry in promoting industrialization and human resources development, and the roles of the Ministry of Education and the private sector, both traditional and modern, cannot be explained by policy intention alone. Successes and failures have to be examined along with their causal and incidental factors including: strong and sustained government commitment and support; the government's roles as direct provider and regulator taking into account the stage of technological development, building domestic capacity to develop human resources at appropriate skills and knowledge levels, existence of and collaborative relationship with the private sector including the traditional sector, reasonable pace of acquisition and internalization, matching skills development with needs, cost-effectiveness and self-reliance in the process and finance.

Needless to say, however, the assessment made has to be interpreted with care, especially when it comes to what lessons can be drawn with respect to present-day developing countries. The pace of technological innovation, the product cycle of strategic output, international factor mobility, and the presence or absence of international aid together make up a very different environment for Meiji Japan as compared to that of current developing countries. Notwithstanding these differences, many of the factors that have been found to be key to the success of the countries which over the last half century have been able to grow out of underdevelopment were present in the policies and approaches adapted by Japan during the Meiji era.

References

Amano, I. (1997). *Kyouiku to Kindaika – Nihon no Keiken* (Modernization of Education-Japan's Experience), Tamagawa University Press. (Japanese)

Emi, K. (1962). Meiji no Keizaihatten to Kyouikutoushi (Economic Development and Investment in Education in Meiji Era) *Hitotubashi Ronso* Vol.48, No. 6. (Japanese)

Gill, I.; Fluitman, F., and Dar A. (Eds). (2000) *Vocational Education and Training Reform: Matching Skills to Markets and Budgets*. Oxford University Press for the World Bank.

Iida, K. (1980). Origin and Development of Iron and Steel Technology in Japan. A working paper of The Japanese Experience of the United Nations University's Human and Social Development Programme. UNU.

Iida, K. (1981). Kindai Tekkou Gijutsu no Hatten to Roudouryoku (Development of Modern Technology of Iron and Steel and Labor Force). A working paper of The Japanese

Experience of the United Nations University's Human and Social Development Programme. UNU. (Japanese)

Iwauchi, R. (1989) *Nihon no Kougyouka to Jukuren-Keisei* (Japan's Industrialization and the Formation of Skilled Workers). Nihon-Hyoronsha (Japanese).

Monbusho (1962). *Nihon no Seicho to Kyouiku – Kyouiku no Tenkai to Keizai no Hatten* (Japan's Growth and Education: Development of Education and Development of Economy). (Japanese).

Monbusho (1981). Gakusei Hyakunenshi (One Hundred Years of Education System). Tokyo: Teikoku Chihou Gyousei Gakkai (in Japanese).

Nakaoka, T. (1986). Gijutu-Shi no Shiten kara mita Nihon no Keiken (Japanese Experience from the Viewpoint of History of Technology), in Nakaoka, T., Ishii, T., and Uchida, H. *Kindai Nihon no Gijutsu to Gijutsu-Seisaku* (Technology of Modern Time Japan and Technology Policies). UNU Press. (Japanese)

Nakaoka, T. (2006). *Nihon Kindai Gijutu no Keisei – Dentou to Kindai no Dainamikusu* (Formulation of Japanese Modern Technology – Dynamism between Tradition and Modernity). Asahi-Shimbun Publications. (Japanese)

Odaka, K. (2007). Meiji no Oyatoi-Gaikokujin-tachi to Sangyou-Hatten no Kouzu (Hired Foreigners in Meiji and the Structure of Industrial Development). Speech note at the 11th lecture, Lecture Series for the 150th Birth Anniversary of the Founder Masakuni Satta, Hosei University. The Research Institute for Innovation Management, Hosei University ed. (Japanese)

Okada, M. (1977). *Tohoku Kaihatu Yawa* (Tohoku Development Night Story). Kinkodo. (Japanese)

Ohashi, S. (1975). *Bakumatsu Meiji Seitetushi* (A History of End of Edo-Meiji Steel Making). Hakushinsha. (Japanese)

Ohno, K. (2006). The Economic Development of Japan: The Path Traveled by Japan as a Developing Country. GRIPS Development Forum.

Tohata, S. (1964). *Nihon Sihonshugi no Keiseisha – Samazama no Keizai-Shutai* (Those Who Formulated Japanese Capitalism: Numerous Economic Actors). Iwanami Shoten. (Japanese)

Uchida, H. (1986). Gijutsu Seisaku no Rekishi (History of Technology Policies) in Nakaoka, T., Ishii, T., and Uchida, H. *Kindai Nihon no Gijutsu to Gijutsu-Seisaku* (Technology of Modern Time Japan and Technology Policies). UNU Press. (Japanese)

UNESCO Institute for Statistics (UIS) (2010). *Global Education Digest 2010.* Montreal: UIS.

World Bank databank [http://databank.worldbank.org] (accessed on September 7, 2010).

Yoshida, K. (2007). Saiko suru Sukiru Diberopumento heno Kokusai-Kyoryoku (Revival of International Cooperation for Skills Development: Old Wine in a New Bottle?). *Journal of International Cooperation in Education*, Vol. 10. No. 3:73-89. Center for the Study of International Cooperation in Education, Hiroshima University. (Japanese)