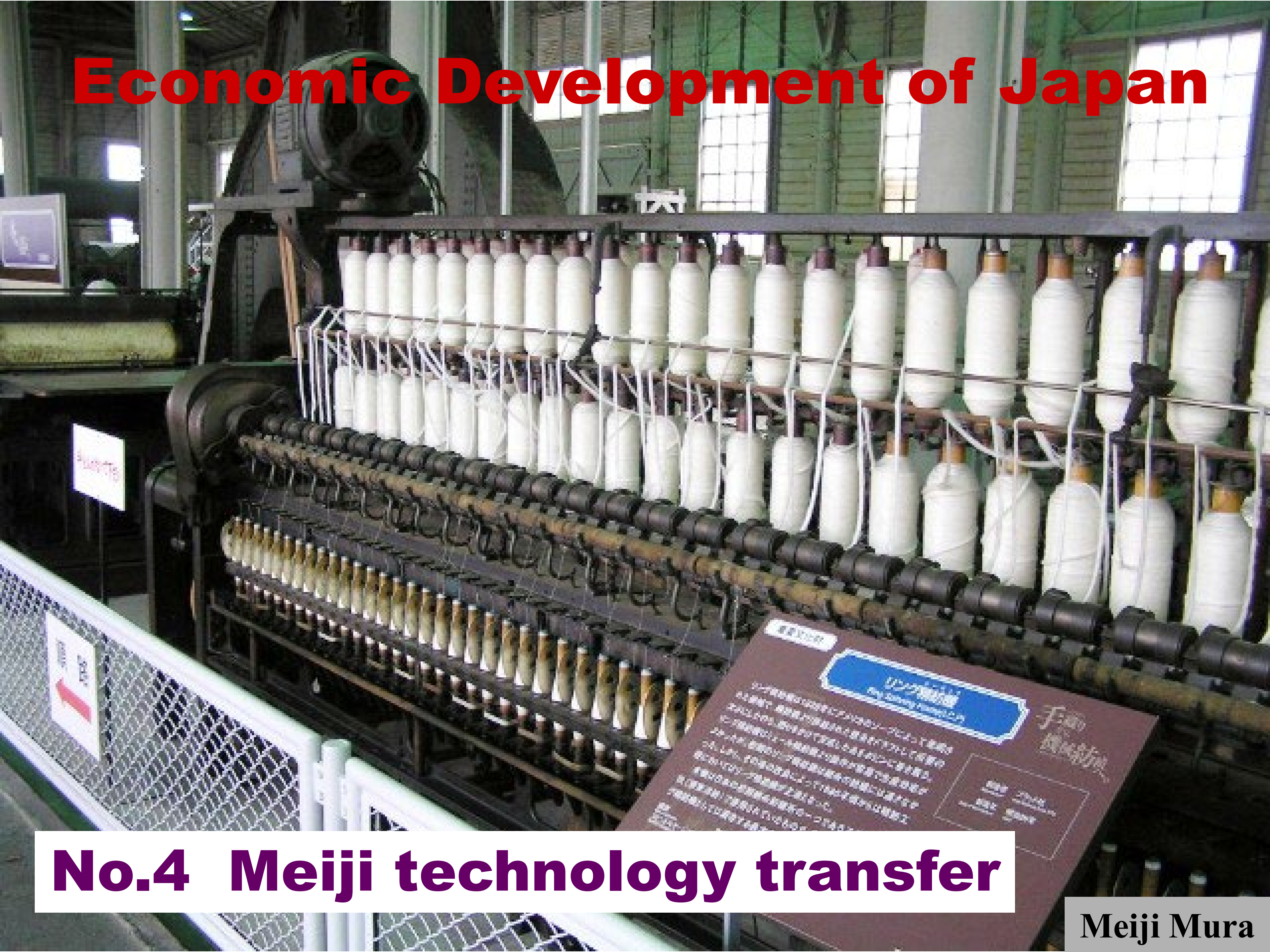
Economic Development of Japan



No.4 Meiji technology transfer

Meiji Mura

Topics for Discussion

- How did Japan learn Western technology in the Meiji period? Give concrete methods and examples.
- Explain the relationship between the learning method and speed on the one hand and the absorptive capacity of Japanese engineers and workers on the other hand.
- What were the leading industries that supported Japan's Industrial Revolution around the 1890s? How did private effort and policy support interact?
- Describe the Japanese labor market situation during the late 19c and the early 20c—labor quality and characteristics, labor surplus or shortage, rural-urban migration, and wages.

Learning Western Technology

- The most prominent aspect of Meiji Japan's technology absorption was progression from easy to complex in both content and method of technology learning as domestic capability steady rose.
- Learning took place in the following overlapping sequence: (i) Dutch books, (ii) foreign instructors on site, (iii) turnkey projects by contracted foreign teams, (iv) sending students abroad, (v) technical universities and schools, (vi) copy production and reverse-engineering from imported machines, and (vii) selective learning through licensing, technical agreements and joint ventures.
- There was a happy blend of strong private dynamism and (mostly) appropriate industrial policy. Private dynamism was the main engine of growth while policy played an important supporting role (a similar situation was repeated in the post-WW2 high growth period).
- Traditional and modern industries co-existed. Old industries from the Edo period were not wiped out by superior Western technology. This was partly because Japanese goods and Western goods were quite differentiated in use, and partly because of learning effort by Japanese traditional industries.

Reading Dutch books

- In 1854, Japan needed cannons for coastal defense. Relying solely on (outdated) Dutch books, some hans mobilized scholars and craftsmen to build furnaces for casting cannons. But haphazard copy production of steel and arms generally failed.
- Some hans also test-produced Western-style ships and steam engines from Dutch texts, but results were far inferior to real Western ships.

Working under Foreign Instructors

- Construction of a Western-style wooden ship at Heda port in the Izu Peninsula in 1854, where carpenters worked under Russian naval officers and shipwrights, was the first successful on-site technology transfer. Japanese carpenters absorbed the technology very quickly.
- Nagasaki Naval Training Center, established by Dutch assistance in 1855, taught the crew of Western-style battleship. Five Dutch navy officers trained 167 samurais in navigation, artillery and engine maintenance. Graduates later operated many of the 166 ships imported by the Edo government and hans.

Turnkey Projects by Foreign Contractors

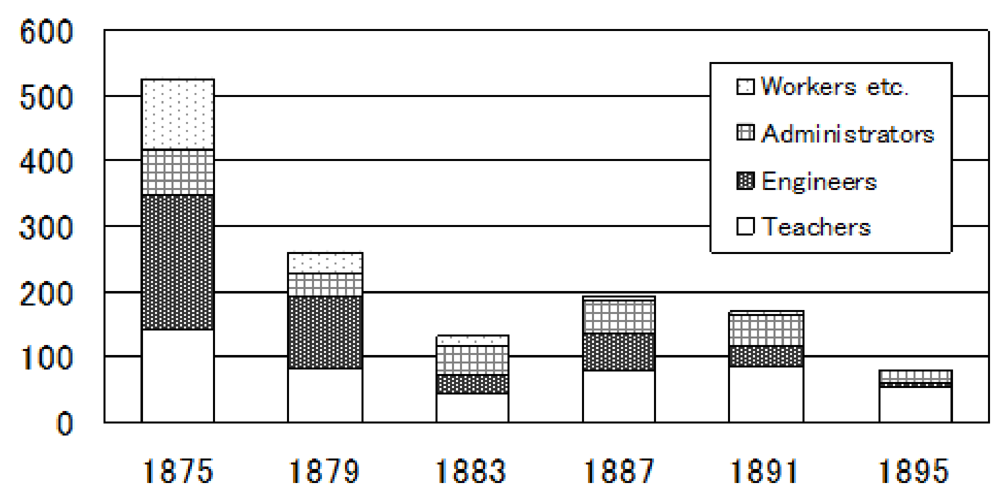
Japan's first railroad from Shimbashi to Yokohama, 1872

- In early Meiji, government hired 300 to 600 foreign advisors in any year on project contract basis to establish Western style state-owned railroads, telegraphy, silk reeling, etc. as quickly as possible.
- Each project commissioned a large foreign team, usually of the same nationality, who imported all materials to create an exact replica of a foreign model. Japanese workers took over operation after project completion.
- Yokosuka Shipyard, Tokyo-Yokohama Railroad, Imperial Mint and Ikuno Silver Mine were four biggest such projects. There were also many other projects as well as foreign advisors hired individually.
- Speed, not technology transfer, was the main aim of turnkey projects, but many Japanese workers became competent machine operators, steam engine drivers, steelworkers and electricians. Many migrated to the private sector or set up their own factories, spreading new technology and management.

Replacing Foreign Advisors with Japanese

- Some foreign advisors received salaries higher than that of the prime minister. In 1874, their payrolls accounted for 34% of the operational budget of the Ministry of Industry.
- Government hoped to replace them with Japanese as soon as possible. It stopped new turnkey projects around 1875. Foreign engineers disappeared from all but a few state-owned projects by 1880.
- The private sector also hired foreign advisors. Many foreigners taught foreign languages (most hired Americans were English teachers).
- By the late 1890s, to set up a national telephone network, Japanese officials visited UK, US & Germany, compared their systems and negotiated with foreign manufacturers. They no longer needed any foreign advice.

Foreign Advisors Hired by the Meiji Government



Dispatching Students Abroad

- In 1862, the Bakufu sent seven students to the Netherlands for naval training (associated with Bakufu's battleship order).
- By the 1880s, 80 Japanese students had studied engineering abroad (shipbuilding, mechanics, civil engineering, mining and metallurgy, military, chemistry). They were sent to UK (28), US (20), France (14), Germany (9) and Netherlands (8).
- Japanese students received top-class education and could easily replace foreign advisors upon returning to Japan.
- They mostly worked as government officials and contributed to policy making at the Ministry of Interior, Ministry of Finance, Army, Navy, Ministry of Industry, etc. At that time, few modern private industries existed to receive them.

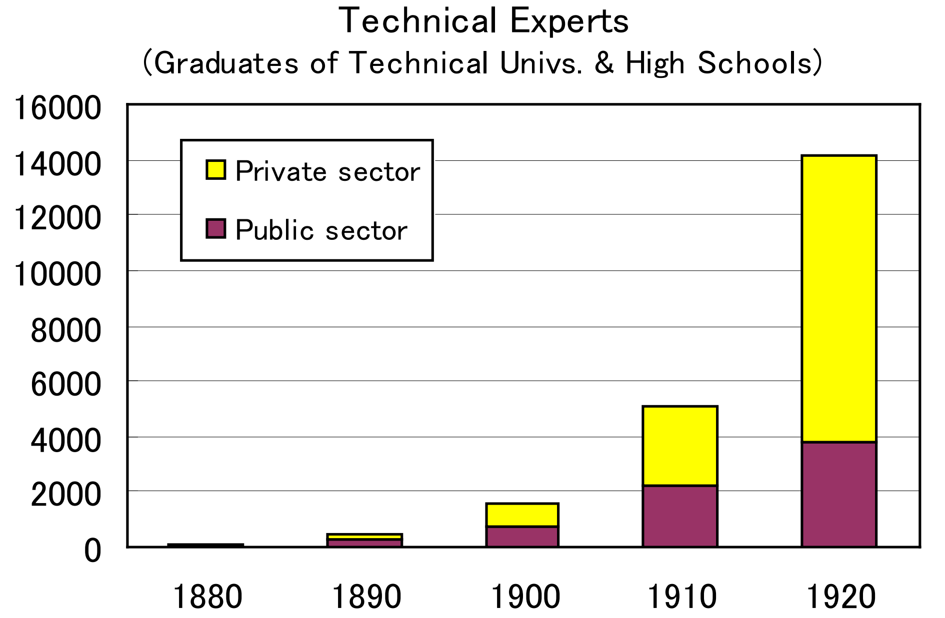
First Japanese students sent abroad by Bakufu (and their friends), photographed in the Netherlands, 1865

Domestic Engineering Education

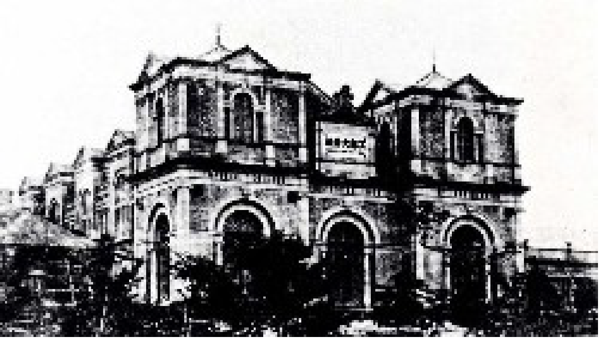
- **The Institute of Technology** produced top-level government officials who guided and accelerated Japanese industrialization.
- **High-level Industrial Schools** offered practical knowledge and skills for engineers and technicians who worked on factory floors.
- **General trading houses** (*sogo shosha*) such as Mitsui Bussan, Okura and Takada also hired engineers to assist manufacturing firm customers through provision of technical information, selecting right models and producers, import procedure, installing equipment, etc.

Private-sector experts, 1910

Mining	513 (18.0%)
Textile	300 (10.6%)
Shipbuilding	250 (8.8%)
Power & gas	231 (8.1%)
Trading	186 (6.5%)
Railroad	149 (5.2%)
Food	149 (5.2%)
TOTAL	2,843 (100%)



Here, experts are those who studied abroad or graduated from formal engineering and technical education.



Kobu Daigakko 工部大学校
(Institute of Technology)

- 1871, *Koburyo* (Industrial Training School) established by the Ministry of Industry; 1877, renamed to *Kobu Daigakko*; 1886, merged with Tokyo Imperial University under the Ministry of Education.
- The first Rector was Henry Dyer, a hired British engineer with a philosophy of "judicious combination of theory and practice."
- The six-year program included preparatory course (language & math, 2 years), specialized studies (2 years), internship at government project (2 years). Top students were additionally sent overseas with scholarship.
- Courses were: (i) civil engineering, (ii) mechanical engineering, (iii) shipbuilding, (iv) telecommunication, (v) chemistry, (vi) architecture, (vii) metallurgy, and (viii) mining. Classes were given mostly in English.
- Top-class engineers were produced including Tanabe Sakuro (designer of Biwako-Kyoto irrigation canal & power generation); Tatsuno Kingo (designer of Tokyo Station, Bank of Japan building, Nara Hotel, etc.)

Student notebook at Kobu Daigakko

(calculating the maximum signal transmission speed through a cable)

$$\log\frac{R}{r}$$

Again if the specific resistance of the conductor is constant

$$S = \frac{r^2}{\log\frac{R}{r}} \times \text{constant } (\kappa)$$

Now to find the maximum value of S

$$\frac{dS}{dr} = K\left(\frac{r^2 \times \frac{r}{R}\cdot R \cdot \frac{1}{r^2} - 2r\cdot\log\frac{R}{r}}{\left(\log\frac{R}{r}\right)^2}\right) = 0$$

that is when

$$K\cdot\frac{r\left(1 - 2\log\frac{R}{r}\right)}{\left(\log\frac{R}{r}\right)^2} = 0$$

that is when

$$1 - 2\log\frac{R}{r} = 0$$

or $$\log\frac{R}{r} = \frac{1}{2}$$

$$\therefore \quad \varepsilon^{\frac{1}{2}} = \frac{R}{r}$$

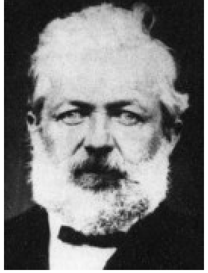
or $$\frac{R}{r} = 1.65$$

or $$\frac{R-r}{r} = .66 = \frac{2}{3}$$

That is the speed of signal is maximum when the diameter of the conductor is twice the thickness of the dielectric of the cable

Koto Kogyo Gakko 高等工業学校

(High-level Industrial Schools)


Wagener


Tejima

- High-level Industrial Schools were proposed by Gottfried Wagener (hired German engineer) and Tejima Seiichi (Ministry of Education official). The first such School was established in Tokyo in 1881.
- Students were recruited from *chugaku* (high school, about age 16-17) through exam, but best students were accepted without it. Mechanical engineering and chemical engineering were initially offered. More courses were added later.
- Unlike Kobu Daigakko, instructors were all Japanese except Wagener. *Tokyo Kogyo Gakko* became the leading institute for supplying industrial instructors, factory managers, engineers and entrepreneurs. After the Great Kanto Earthquake of 1923, Tokyo Kyogo Gakko relocated to O-okayama (Meguro-ku, Tokyo). It is now the Tokyo Institute of Technology.
- Seven more Schools were created in Osaka (1901), Kyoto (1902), Nagoya (1905), Kumamoto (1906), Sendai (1906), Yonezawa (1910) and Akita (1910). After Meiji and until 1945, twenty-three more Schools were added.
- After WW2, most High-level Industrial Schools were transformed into faculties of engineering of national universities.

Number of Japanese Engineers
(By Type of Education)

Employer	Category of engineer	1880	1890	1900	1910	1920
Government departments and agencies	Early Meiji-era engineers	61	72	-	-	-
	University graduates	25	183	474	1,075	1,795
	Industrial school graduates	-	45	263	1,160	1,999
	Subtotal :	86	300	737	2,235	3,794
Private organizations	Early Meiji-era engineers	-	17	54	34	-
	University graduates	-	131	385	846	3,230
	Industrial school graduates	-	34	389	1,963	7,138
	Subtotal :	-	182	828	2,843	10,368
Total	Early Meiji-era engineers	61	89	54	34	-
	University graduates	25	314	859	1,921	5,025
	Industrial school graduates	-	79	652	3,123	9,137
	Grand total :	86	482	1,565	5,078	14,162

Source: Uchida (1990), p. 281.

Learning from Imported Machinery

- When battleships were ordered to UK, Japanese engineers travelled to UK to observe construction. This provided ample opportunity to learn about British ship design and construction, leading to domestic production of arms, support vessels and even principal battleships.
- Government imported ten sets of cotton spinning equipment. After installing and test running, they were sold to the private sector as ten separate cotton mills with government engineers assisting operation.

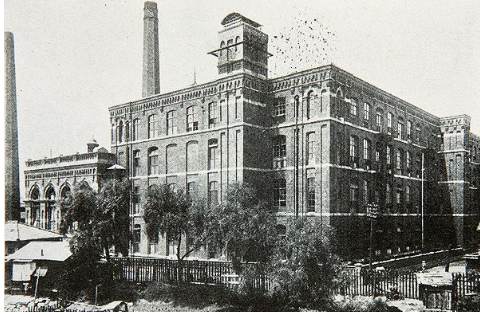
More Selective Learning

- From the 1900s, technical cooperation agreements and joint ventures enabled sharply targeted transfer of state-of-art technology.
- For telephone equipment, Western Electric (US) established Nippon Electric Company (NEC) as its Japanese subsidiary in 1899. It was WE's sole agency in Japan receiving technical guidance from WE.
- In 1905, General Electric (US) concluded a technical agreement with Tokyo Electric for producing light bulbs. Tokyo Electric engineers were able to quickly master any new technology developed by GE.

Cotton Textile Industry

- Initially, the government established silk and cotton spinning factories with foreign advisors, technology and equipment. These state-run factories were generally loss-making but had demonstration effects.
- In 1883, Shibusawa Eiichi created Osaka Spinning Company, a private cotton spinning firm with appropriate technology choices. The instant success of Osaka Spinning led to the emergence of similar private cotton spinners.
- Import substitution proceeded from importing finished products to importing yarn (intermediate product) and finally to importing raw cotton. An officially supported cartel was created to import Indian raw cotton for Japanese spinners exclusively by a Japanese marine transporter (Nippon Yusen).
- As domestic competition intensified, production expanded from spinning to weaving (downstream), and from import substitution to export. After the business recession around 1900, weak spinners were eliminated and Big Five began to dominate Japanese cotton textile industry (Dainippon, Kanebo, Toyobo, Godo and Fujibo).
- Meanwhile, traditional smaller-scale textile producers were not wiped out. They were mainly engaged in weaving and gradually improved methods.

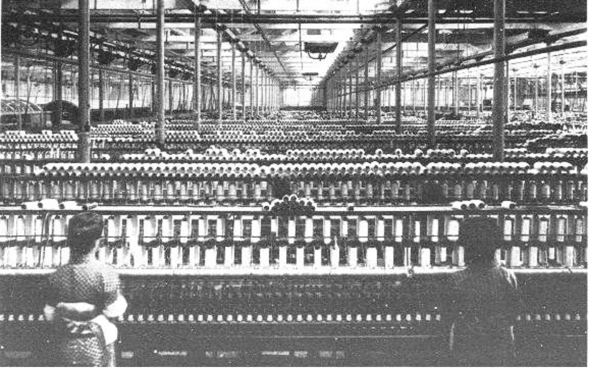
Osaka Boseki (Spinning) Company

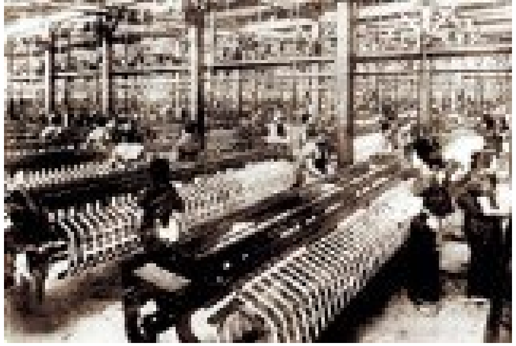


- Osaka Boseki, a private joint stock company, was Japan's first successful modern cotton spinning factory established in 1883 by Shibusawa Eiichi.
- Shibusawa asked Yamanobe Takeo, studying in the UK, to absorb practical knowledge of cotton industry, place machinery orders before returning to Japan, and establish Osaka Spinning with Shibusawa.
- Osaka Spinning was an instant success with many follower companies. Reasons included (i) a large operation scale and latest Ring machines; (ii) sufficient funding; (iii) use of steam power instead of water power which permitted urban location; (iv) use of imported Chinese cotton; (v) 24-hour/2-shift operation; and (vi) Shibusawa's overall support.
- However, Osaka Boseki's shareholders demanded quick dividends while Yamanobe, factory manager, wanted to invest in technology and equipment for expansion. Yamanobe wanted to quit, but Shibusawa encouraged him to stay.
- Yamanobe persisted and was later promoted to the General Director.

Shibusawa Eiichi
1840-1931

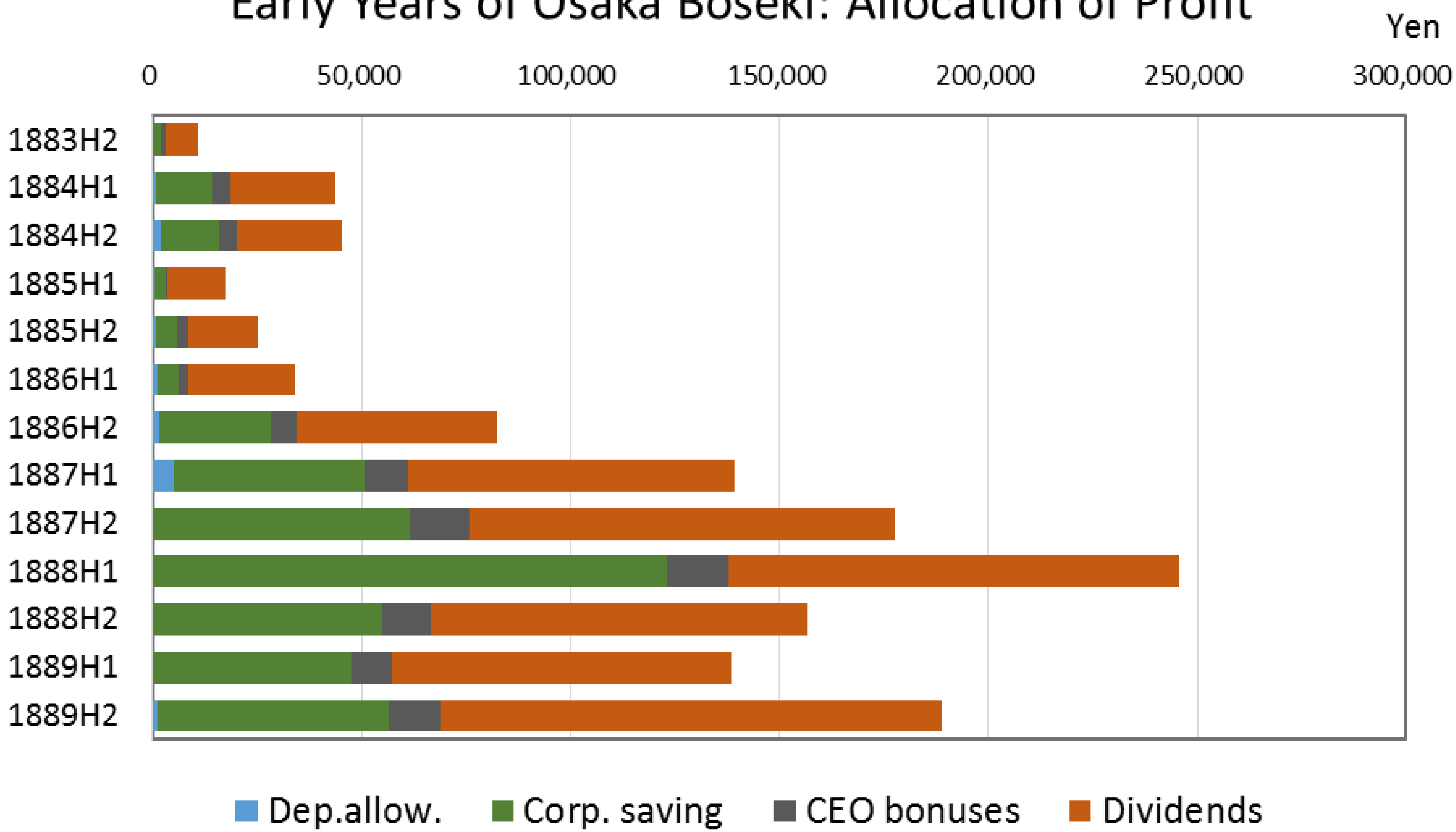
Yamanobe Takeo
1851-1920



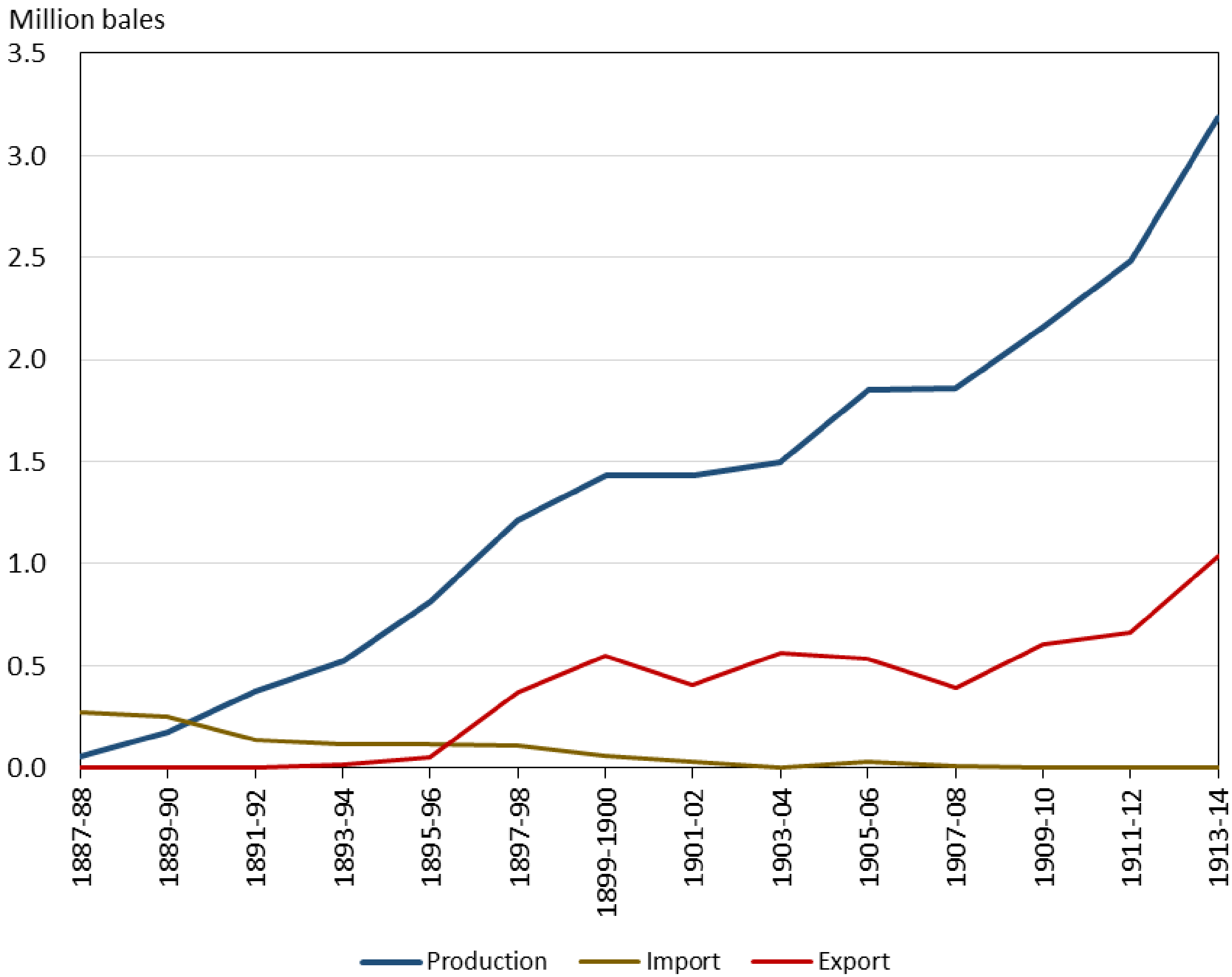


From the first year of operation, Osaka Boseki was profitable. Profits were roughly equally divided between corporate saving for expansion and dividends for investors.

Early Years of Osaka Boseki: Allocation of Profit



Production, Import and Export of Machine-spun Cotton Yarn



Import declined as domestic production rose strongly. By the late 1890s, Japan became an exporter of cotton yarn.

Source: Naosuke Takamura, *Introduction of the History of Japanese Cotton Spinning Industry*, Hanawa Shobo, 1971, as cited by Abe Takeshi Abe, "Cotton Industry," in S. Nishikawa and T. Abe, eds., *Japanese Economic History vol. 4: The Age of Industrialization 1*, Iwanami Shoten, 1990, p.168.

Steel Production

- During 1885-1914, Japan's steel production covered about 20% of domestic demand (estimated by Suzuki, 2000), much lower than France (90%), Germany (70%) or US (70%). These countries had high steel protection tariffs (20-100%) compared with Japan (5%).
- Japanese steel mill in Kamaishi (private) could not compete with imports without tariff protection of 30% or higher.
- In 1901, government built a large-scale modern mill in Yawata, Kyushu to become Japan's largest mill in the pre-WW2 period.
- With the outbreak of Japan-Russia War in 1904, steel demand greatly increased.
- As the tariff right was regained, steel tariffs were raised to 5-10% in 1899 and to 10-20% in 1911. This encouraged Mitsui and Mitsubishi to start investing in steel production.

Struggles at Kamaishi

- Oshima Takato from Nambu Han (traditional iron-making han in Northeastern Japan) built a Western style furnace using charcoal and watermill in 1857. But production remained small and inefficient.

Oshima

- In 1873, Meiji government took over Kamaishi Works with German advice and British equipment. However, its operation encountered many technical problems. Government gave up on Kamaishi in 1882.
- In 1885, Tanaka Chobei, a Tokyo merchant, his son & son-in-law took over Kamaishi and continued to adjust production method. In 1892, Noro Kageyoshi, a Ministry of Agriculture and Commerce official with engineering knowledge, began to assist Kamaishi.

Tanaka

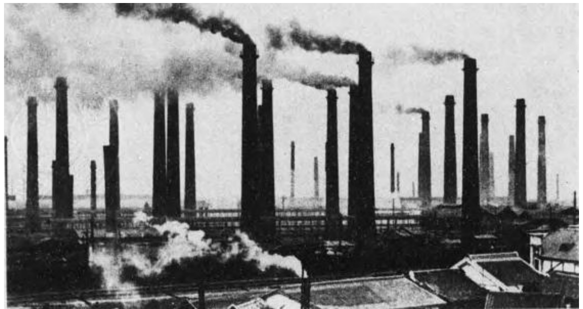
- In 1894, Kamaishi succeeded in coke-based iron production for the first time in Japan. Meanwhile, steel making was undertaken by military factories. Iron making and steel making were not yet integrated (steel making, or removing carbon content from iron, is a downstream process from iron making).

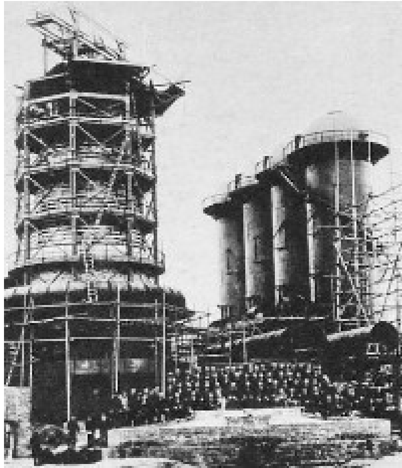
Noro

Yawata Iron & Steel Works

German Technology + Japanese Adjustments

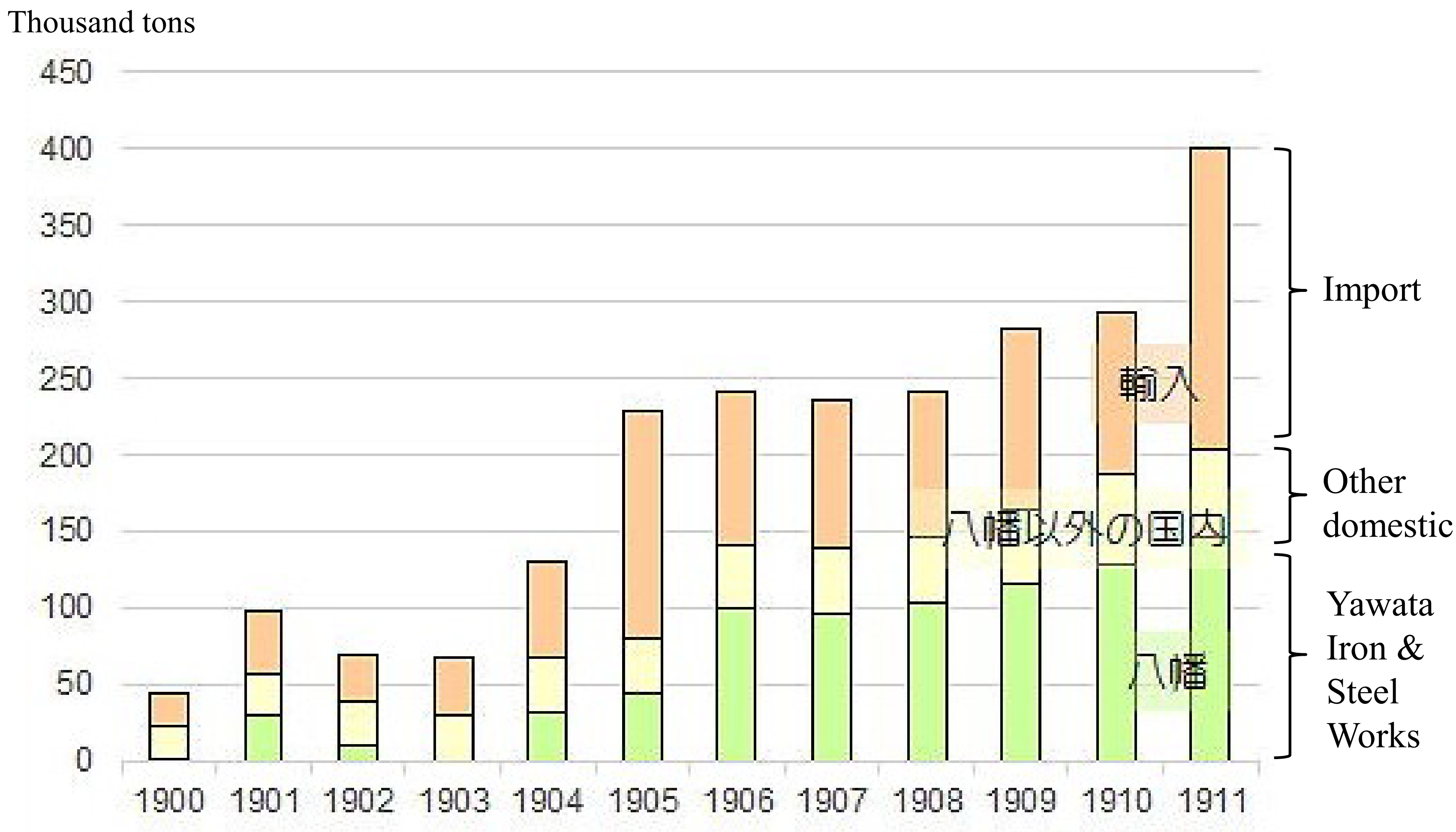
- In 1895, government decided to build a state-of-art steel mill.
- For funding, reparation from China was partially used (Japan-China War, 1894-95). After research, German technology of GHH was selected. Many German engineers were hired with high salary for construction and operation.
- The first blast furnace started operation in 1901. However, output was low, loss was made, and operation stopped due to the lack of coke oven and poor iron ore content. Government built a coke oven and carefully selected materials and called Kamaishi engineers for help.
- Japanese experts adjusted the blast furnace and operation method. In 1905, production became normal and smooth. From 1906 onward, Yawata's capacity was expanded in many aggressive steps to become the largest steel producer in pre-WW2 Japan.





Production and Import of Pig Iron

Domestic iron supply from Yawata & others rose but import also continued



Source: Shinobu Oe, *Japanese Industrial Revolution*, Iwanami Shoten, 1968.

Subsidies for Targeted Industry
The Case of Marine Shipping and Shipbuilding

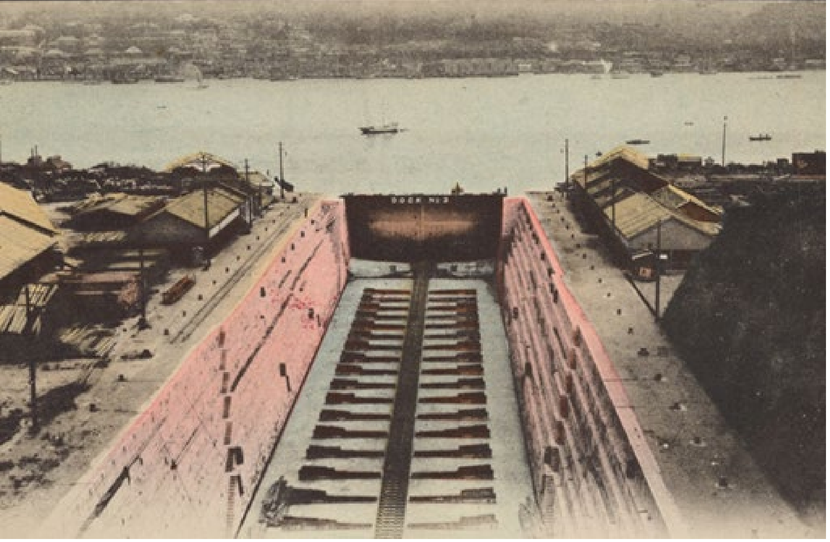
- **Navigation Promotion Law** (1896) subsidized marine transport operators provided that they (i) operated international routes, (ii) used large ships over 1,000 tons, or (iii) used fast domestic ships. These targets were raised in steps while more incentives were offered.
- **Shipbuilding Promotion Law** (1896) subsidized building of steel ships over 700 tons (later 1000 tons).

Financial Structure of Nippon Yusen

Million yen

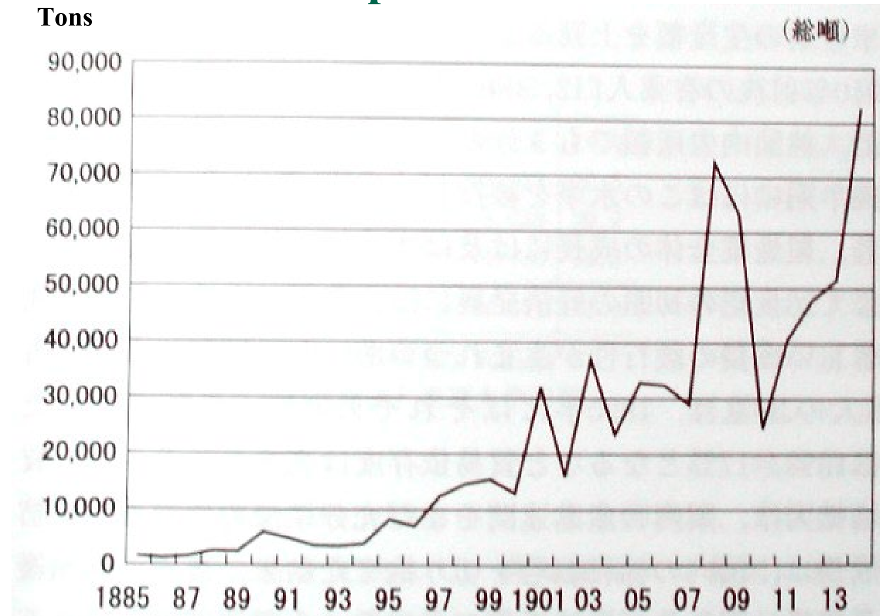
	Revenue	Subsidy	Cost	Profit
1886-90	21.8	4.4	21.3	4.9
1891-95	33.0	4.5	28.3	9.2
1896-00	59.6	14.9	63.1	11.4
1901-05	94.5	18.9	92.6	20.8
1906-10	108.3	26.0	118.9	15.4
1911-15	145.5	24.0	141.7	27.8

Nippon Yusen (now NYK Line), the leading marine transporter under Mitsubishi, benefited greatly from government subsidies, even to the extent that loss was turned to profit thanks to subsidies in some years.



No.3 Mitsubishi Dock-yard Nagasaki completed in 1905, circa 1907-1918.

Ship Construction



Subsidies Received by Shipbuilders

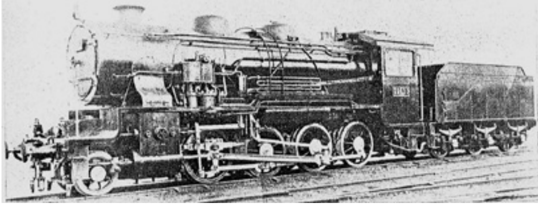
Thousands of yen

	No. of ships built	Subsidies received for				
		Total	Tonnage	Ship	Horsepower	Engine
Mitsubishi	43	6055.5	207.4	5146.4	181.8	909.0
Kawasaki	34	2379.0	96.7	1912.0	93.4	467.0
Osaka	30	618.7	30.5	478.3	24.1	140.4
Ishikawajima	2	53.0	2.5	43.0	2.0	10.0
Ono	1	12.2	0.8	9.5	0.5	2.7
Uraga	2	47.8	2.7	47.8	0.0	0.0
TOTAL	113	9166.2	340.6	7637.0	301.8	1529.1

Shipbuilding companies received subsidies for various reasons. Mitsubishi and Kawasaki were the industry leaders followed by Osaka. Ishikawajima, Ono and Uraga were much smaller.

Source: Yoshio Ando (ed), *Databook on Modern Japanese Economy*, 2nd ed., Univ. of Tokyo Press, 1979.

Railroad Rolling Stock



- State-owned factories, such as Shimbashi and Kobe, produced three-fourths of 5,000 railroad carriages manufactured in Meiji. Later, state-owned factories confined themselves to repairs, improvements and technically supporting private factories.
- Private factories that received official support included Kisha Seizo, Kawasaki Shipbuilding, Hyogo Factory (Sanyo Railway), Omiya Factory (Nippon Railway) and Kokura Factory (Kyushu Railway).
- Production of locomotives was undertaken by close cooperation of government and private firms. In 1912, the Railroad Agency designated Kisha Seizo, Kawasaki Shipbuilding, Nippon Sharyo and Amano as suppliers of locomotives. To enhance their capacity, the Agency provided design and materials, coached copy production, and dispatched engineers abroad for absorbing technology.
- The stable and large orders from the Railroad Agency also offered incentives for private firms to invest and learn technology.

Source: Minoru Sawai, "Machinery Industry," S. Nishikawa & T. Abe, eds, *Japanese Economic History vol. 4: The Age of Industrialization 1*, Iwanami Shoten, 1990, p.228.

Balanced Growth of Meiji

Source: Kyoji Fukao, Japanese Growth and Stagnation from the Perspective of World Economic History (2020)

Growth occurred relatively uniformly across sectors and prefectures.

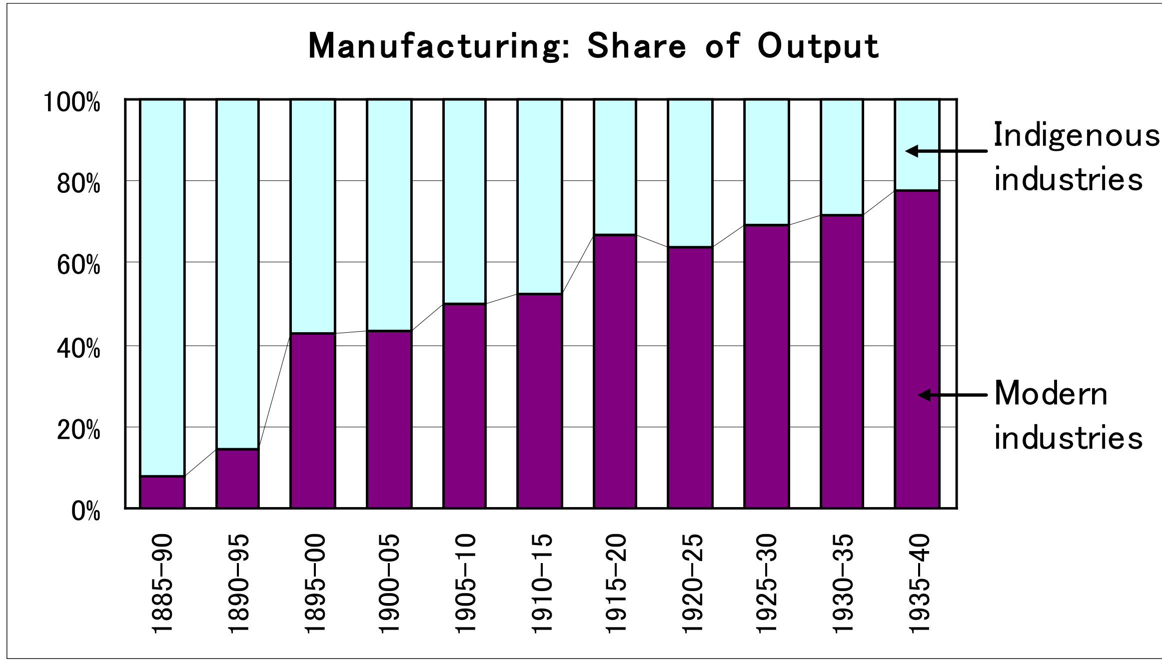
- Structural transformation (shift from agriculture to manufacturing & services) was in progress.
  - Agriculture's GDP share: 60% (1874) ➔ 44% (1890) ➔ 36% (1913)
  - Agriculture's labor share: 71% (1874) ➔ 62% (1890) ➔ 58% (1913)
- From 1874 to 1913, estimated labor productivity rose 71% in agriculture and 79% in other sectors (manufacturing & services).
- Reasons for labor productivity growth in agriculture may include movement of surplus labor to other sectors (free labor mobility but within same prefecture) and improved farming technique.
- Regional gaps in income and labor productivity were relatively small (though Osaka and Tokyo were higher than others). Manufacturing rose in all prefectures, not just urban areas. Labor movement across prefectures was limited.

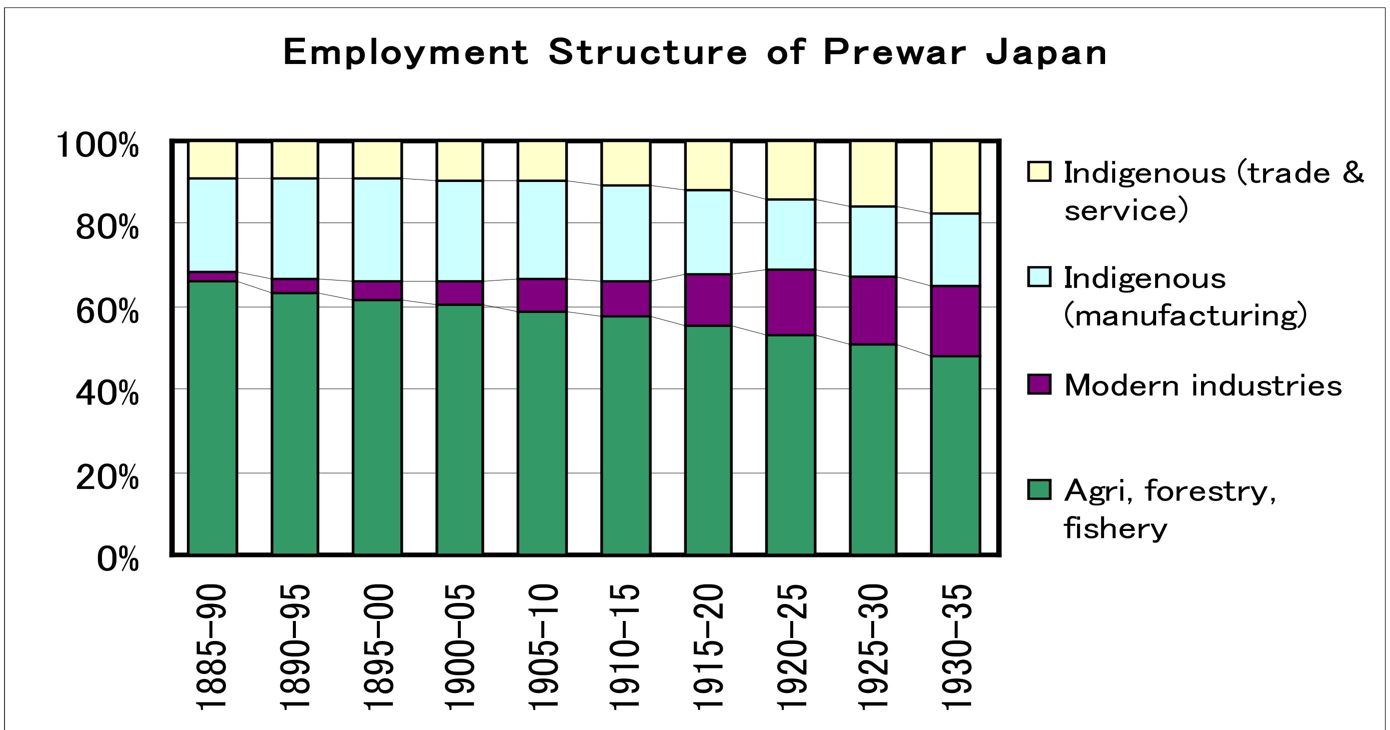
Parallel development or "hybrid technology"

by Konosuke Odaka

		Factory size	
		Small	Large
Technology	Indigenous	I	I*
	Modern	M*	M

* indicates hybrid status



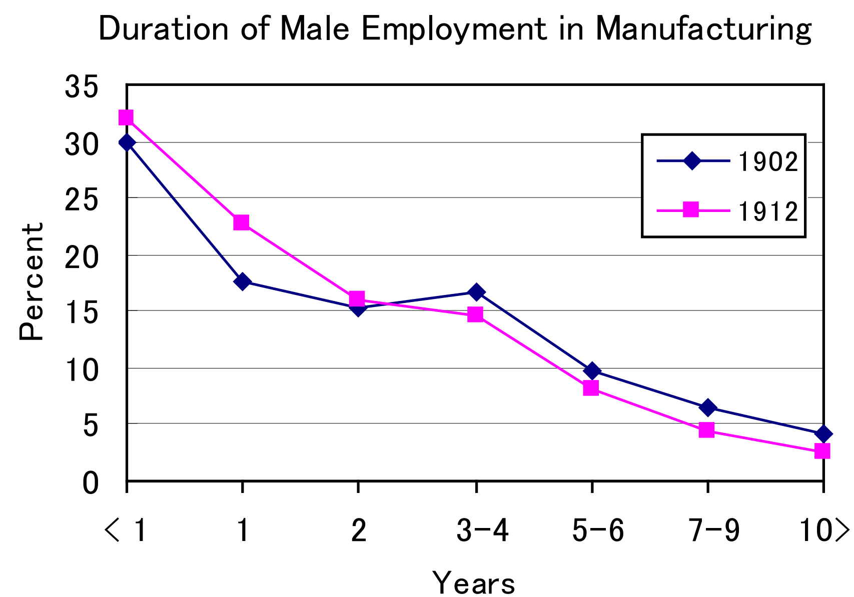


Neoclassical Labor Market

Japanese workers:

- Too much job hopping, do not stay with one company
- Lack of discipline, low saving
- Barrier to industrialization

Source: Ministry of Agriculture and Commerce, *Survey of Industrial Workers*, 1901.



Female domestic workers:

- Urban industrialization and rural poverty and labor surplus
  ➔ female migration from villages to cities
- End of Meiji to early Showa were the peak period of *jochu* (housemaid)
- 17.5% of non-farm female workforce, second largest after textile workers (1930)
- 5.7% of households hired *jochu* (1930)
- There were both young and old *jochu*, some living-in and others commuting
- International comparison (female non-farm employment share): UK 1851 (11.4%), US 1910 (11.8%), Thailand 1960 (10.6%), Philippines 1975 (34.3%)

Source: Konosuke Odaka, "Dual Structure," 1989.

Wage: Gender Gap

	Farm employment Sen per day			Textile weavers Sen per day			Domestic servants Yen per month		
	Male	Female	F/M %	Male	Female	F/M %	Male	Female	F/M %
1885	15.1	9.7	64.2%	12.3	7.5	61.0%	1.38	0.75	54.3%
1892	15.5	9.4	60.6%	12.0	8.4	70.0%	1.55	0.82	52.9%
1895	18.5	11.3	61.1%	18.3	11.6	63.4%	1.64	0.90	54.9%
1900	30.0	19.0	63.3%	33.0	20.0	60.6%	2.70	1.56	57.8%
1905	32.0	20.0	62.5%	34.0	13.0	38.2%	3.22	1.79	55.6%
1910	39.0	24.0	61.5%	49.0	27.0	55.1%	4.56	2.96	64.9%
1915	46.0	29.0	63.0%	46.0	30.0	65.2%	4.97	3.13	63.0%
1920	144.0	92.0	63.9%	175.0	95.0	54.3%	28.86	22.68	78.6%

Source: Ministry of Agriculture and Commerce, "Table of Wages."
Note: 1 yen = 100 sen.

Konosuke Odaka: ***World of Craftsmen, World of Factories*** (NTT Publishing, 2000)

- In Japan's early factories, traditional *shokunin* (craftsmen) and modern *shokko* (workers) coexisted.
- Craftsmen were proud, experienced and independent. They were the main force in initial technology absorption.
- Workers received scientific education and functioned within an organization. Their skills and knowledge were open, global and expandable.
- Trained engineers, not craftsmen, created a modern production system suitable for Japan—adaptation of imported system to Japanese context, production and labor management system, skill formation based on formal education and OJT.
- Over time, craftsmen were replaced by workers. Experience was not enough to deepen industrialization.

Prof. Odaka proves these points by examining the history of concrete firms in metallurgy, machinery and shipbuilding.

Key Ideas for This Lecture

- Meiji Japan absorbed Western technology in progressive sequence, starting from books and turnkey projects, to ultimately reach selective and sophisticated technology transfer under strong Japanese ownership.
- This was made possible initially by the existence of skilled and curious traditional craftsmen, later by an increase of competent engineers through a new formal education system. Over time, the latter group became dominant.
- Japanese workers around 1900 were very different from today's. They were lazy, ungovernable, non-saving and frequent job hoppers. Their productivity was only half of American workers. There was a large migration from rural villages to cities.