THE ROLE OF THE GOVERNMENT IN THE EMERGENCE OF HEAVY INDUSTRY IN CHINA, 1865-1911: A Comparative Study of Hupeh and Kiangsu Provinces

SU YUN-FENG

FOREWORD

Heavy industry is the foundation of industrialization which, in turn, is the main characteristic of modernization. China reluctantly recognized the superiority of Western science and technology and only gradually decided to learn from the West in the year after the Opium War. The establishment of Kiangnan Arsenal in 1865 in Shanghai by Li Hung-chang (1823-1901), ushered in the period of "military industry". And the installation of Hanyang Ironworks twenty-five years later in Hupeh by Governor-General Chang Chih-tung (1837-1909), brought China into the iron and steel age. These two government enterprises experienced various frustrations and failures, and they had different effects on China's modernization.

So far we have seen many good individual studies on Kiangnan Arsenal and Hanyang Ironworks, but a comparative one is still lacking. Scholars who have worked on Kiangnan Arsenal are Thomas L. Kennedy, (1) Wang Erh-min, (2) Hsieh Yen-keng, (3) and those who have worked on industry in Hupeh

---

Paper presented at the Annual Conference of the Social Science History Association, Nov. 3-5, 1978. Columbus, Ohio. Thank Mr. James Huskey, Mr. Robert Weiss and my colleagues Mr. Wang Shu-hwai and Mr. Chang Yu-fa for their reading and corrections.

(1) Thomas L. Kennedy, "The Kiangnan Arsenal in the Era of Reform, 1895-1911 (*Bulletin of the Institute of Modern History*, Academia Sinica, no. 3, pt. 1, 1972); "The Coming of war at Kiangnan Arsenal, 1885-1895", (*Bulletin of the Institute of Modern History*, no. 7, 1978); and "Industrial Metamorphosis in the Self-strengthening Movement: Li Hung-chang and the Kiangnan Shipbuilding Program", (*Journal of the Institute of Chinese Studies*, Hong kong, 1971).

(2) Wang Erh-min, *Ch'ing-chi ping-kung-yeh te hsin-ch'i* (The emergence of military industries in the late Ch'ing Dynasty), Nankang: Institute of Modern History, 1963.

(3) Hsieh Yen-keng, *Li Hung-chang yu chia-wu chang-ch'ien te pingkung-yeh chien-she* (Li Hung-chang and the military industrial enterprises before the Sino-Japanese War in 1894), Ph. D. dissertation of National Cheng Chih University, 1968.

are Ch'uan Han-sheng,[4] Albert Feuerwerker,[5] Thomas L. Kennedy,[6] and others.

All the books and articles written by scholars mentioned above have dealt with various aspects of the two enterprises such as history, investment, accounting, management, production, causes of failure, etc. They have contributed a great deal to the understanding of industrial development in Kiangsu and Hupeh in particular, and China in general. This paper does not intent to cover the same ground, but rather will concentrate on the problems of men and their ideas, policies, and management, and measures for technology transfer. The problems of men and their ideas and policies, will show to the basic differences between the industrial systems in the two provinces, while the problems of management and technology will illustrate the common causes of failure. In terms of an industrial system, the two cases are entirely different, for the Kiangnan Arsenal limited its scope to the manufacture of military weapons and naval vessels. It neither served as a vehicle to promote the domestic mining and steel industry nor provided a better linkage to the private light industry in Shanghai. It was only after the separation of the Kiangnan Shipyard from the Arsenal in 1905 that we see an improvement in the area of shipbuilding. In Hupeh, however, there was a rather different picture. The Hanyang Ironworks, at the center of development in the area was linked backward to the mining and raw materials industry, and forward to industries of military, transportation, and machinery production. The forward linkage was belatedly formed and was rather loose. On the other hand, the backward linkage was quite successful. The differences between the two industrial systems can be found in an analysis of Li Hung-chang and Chang Chih-tung's perceptions of industry and policies.

In the process of industrialization of an underdeveloped country, the government not only can play a role as a promoter but also should play an

(4) Ch'uan Han-sheng, *Hanyehping kung-ssu shih-lueh* (A brief history of the Hanyehping Iron and Coal Mining and Smelting Co., 1890-1926), HK: The Chinese University of Hong Kong, 1972.

(5) Albert Feuerwerker, *China's Early Industrialization: Sheng Hsuan-huai* (1844-1916) *and Mandarin Enterprise*, Cambridge: Harvard University Press, 1958; "China's Nineteenth-Century Industrialization: the Case of the Hanyehping Coal and Iron Co,, Ltd.", (C. D. Cowan, ed., *The Economic Development of China and Japan*, London, 1964).

(6) Thomas L. Kennedy, "Chang Chih-tung and the Struggle for Strategic Industrialization: the Establishment of the Hanyang Arsenal", (*Harvard Journal of Asiatic Studies*, no. 33, 1973), etc.

entrepreneurial or managerial role. What roles did the two provincial governments play as modern entrepreneurs? In addition, the problem of industrialization can be seen as a problem of technology transfer. It not only involves the role of foreign engineers and technicians, which in turn is closely related to the government's policy of recruiting and employment, but also involves the long term educational policy of domestic technical man-power training. These are the key areas that this paper will emphasize.

However, there are many difficulties in such a comparison. First, there is a time-lapse of 25 years between the establishment of Kiangnan Arsenal and of the Hanyang Ironworks. Theoretically, the later factory should be able to take advantage of the experience of the earlier one. Secondly, the two cases consisted of different kinds of industries. Kiangnan Arsenal was a military industry, while Hanyang Ironworks was a basic ferrous metallurgy industry. Thirdly, there were no consistent documents and statistics that could be compared on the same basis. With these difficulties in mind, this author rather intends to compare the two cases from the viewpoints of their internal management and external linkages, hoping that he may add something new to the general knowledge already contributed by the scholars mentioned above.

I. THE OFFICIALS' PERCEPTIONS OF INDUSTRY AND POLICIES

It has been established by historians that government was the sole promoter of modern industries in late imperial China. However, the point here is to emphasize that it was the *provincial* governments which took the initiatives. The central government always hesitated to give its support, and due to the weakness of the central government, there was widely varying development of regional industries because of the different perceptions of the local officials. In the case of Kiangsu province, the important initial promoter was the Governor-General Li Hung-chang. In Hupeh, it was Governor-General Chang Chih-tung.

Li Hung-chang has been recognized as the most outstanding and farsighted leader among his contemporaries, (7) and yet, his conception of industry was still nascent during this period. Before 1869, what he knew of industry was no more than a machine-tooling business, and consisted of buying machine tools

(7) Hsieh Yen-keng, *op. cit.*, p. 191.

to make machines to produce military weapons, ammunition and vessels. (8) The immediate result of this concept was the establishment of the Kiangnan Arsenal. It was not until the 1870's that he gradually enlarged his knowledge of modern industry and economy, and went one step further to a concern over problems of searching for national wealth other than national defense. He proposed that mining, textile, telegraph, steamships and railroads should be developed, that special emphasis should be put upon the mining of coal and iron ore, for it was the real foundation of industry, and that Western technology be adopted and Western capital be utilized. The whole aim of developing these industries was to compete with foreign merchants in China in order to recover the market being lost to them. The China Steamship Company (1873), the Kaiping Coal Mines (1877), and the Shanghai Textile Factory (1882) were founded on these ideas. However, Li's ideas of railroads and telegraph could not escape the confines of a military function due to his conservative social and political environment. (9)

In short, before 1890, Li Hung-chang had roughly perceived of mining, steel and machine manufacture as integral parts of modern industry. But he could not translate all of his ideas into action because of discouragement from his friends and opposition from conservatives. Rather, he had to confine himself to the development of military industry. The nature of industry in the public sector of Kiangsu province therefore was predetermined by these conditions.

Chang Chih-tung was 14 years younger than Li Hung-chang. Li's character was one of moderation, while Chang's was rash and impetuous. Politically, they belonged to two rival parties. Li had been one of the leaders of the self-strengthening movement since the 1860's, while Chang joined the Ch'ing-liu Tang (The Pure Discussion Party), which was culturally conservative and was critical of the self-strengthening movement. To avoid the criticism of being progressive, Li, as mentioned earlier, tended to be moderate in his industrial undertakings. On the contrary, Chang was always ambitious to take more responsibilities. By the time Chang became the Governor-General of Hukwang in 1890 he began to compete for power with Li Hung-chang,

(8) Yung Wing (Jung Hung), *Hsi-hsueh tung-chien-chi* (My life in China and America,) Taipei: Kuang-wen Bk. Co., rpt., 1961, pp. 98, 100.
(9) Hsieh Yen-keng, *op. cit.*, pp. 157-191.

then Superintendent of Trade for the Northern Ports. Chang knew well that the essential instrument for gaining power was to have a military arsenal of his own. But Chang's perception of industrialization expanded very quickly. No sooner had he started to talk about buying an arsenal than he immediately recognized the importance of mining, iron and steel, transportation and consumers' goods industries.

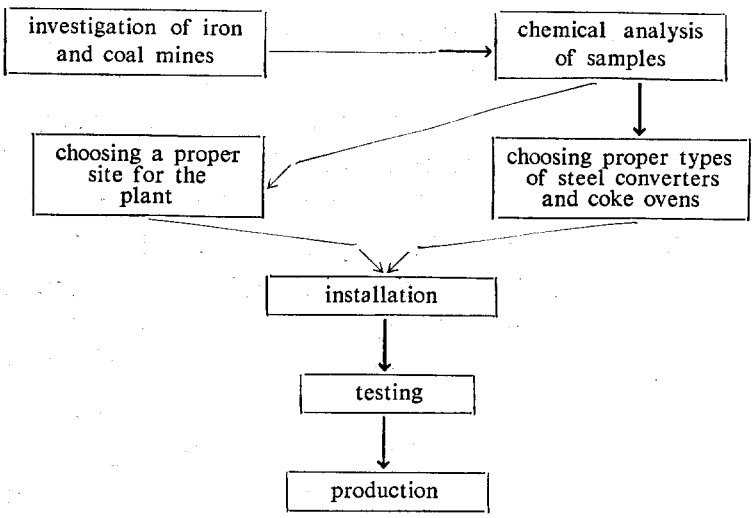
In fact what Chang Chih-tung had in mind in 1890 was a self-sustained system of heavy industry. From his experiences in Canton, he thought that China should use Western technology to build its own iron and steel industry which would, in turn, support military arsenals, machine shops, shipyards, railroad industry, etc. To supply raw materials for the iron and steel industry, he thought there should be simultaneous development of the mining of iron ore and coal, the building of coke ovens for production of coke, and the installation of fireproof material and cement factories to produce material that the ironworks and other industries could utilize. Thus, in theory, Chang had chosen the fast course of industrialization. It was a logical and an integrated course with which the Kiangnan Arsenal could not compare.

However, Chang was wrong in many instances. First, he did not know beforehand the quantity and distribution of the mineral resources. He believed that mineral resources of iron and coal were abundant throughout China, and this proved to be wrong. Second, he did not realize that heavy industry needed vast sums of capital, and this China could not supply. Third, he did not pay sufficient attention to technical man power training. Finally, he was overconfident that all difficulties could be overcome by "the foolish old man spirit" and that industrialization could be realized within a couple of decades. (10) It was for these reasons that Li Hung-chang once told his friends that every one in the Cabinet (Grand Secretariat) knew that Chang was always "talking big and impracticable". (11) Chang erred about the procedure for buying new plants either. The correct process of buying an ironworks should be as follows: (See page 40) By contrary, Chang refused to send ore and coal samples to Germany for chemical analysis, and boldly decided to order the Bessemer Process converters without listening to advice sending back from the Chinese

(10) Chang Chih-tung, *Chang wen-hsiang-kung Ch'uan-chi* (The complete works of Chang Chih-tung), Taipei: Wen-hai Ch'u-pan-she, 1963, hereafter I use the new pagination, v. 4, pp. 2472-3.

(11) *Ibid.*, v. 4, p. 2480.

Ambassador in London. (12) And he was also partially responsible for making the wrong decision choosing Hanyang as the site of the ironworks, for Hanyang was several hundred miles away from iron ore mines in Ta-yeh and coal mines in Ping Hsiang. As a result, the transportation cost represents over 50% of the sale prices of both raw materials. (13) These were the errors that caused so many difficulties for the ironworks in the first several years operation. It was not until 1895 that Chang confessed his mistakes and tried to correct them. (14) But no matter how many mistakes Chang Chih-tung had committed at the beginning, the industrial system thus developed in Hupeh was entirely different from that of Kiangsu.



II. THE INDUSTRIAL SYSTEMS OF THE TWO PROVINCES

1. The Evolution of a Military Industrial System in Kiangsu.

Shanghai has been known as the cradle of modern industries in China. But before 1865 there were only a dozen of modern light industries and eight modern shipyards. These factories and shipyards were entirely owned by foreign merchants. Among the foreign shipyards, the Thomas Hunt and Co., which

(12) *Ibid.*, v. 4, p. 2468.
(13) Ch'uan Han-sheng, *Hayehping kung-ssu shih-lueh*, *op. cit.*, pp. 242-248.
(14) Chang Chih-tung, *op. cit.*, v. 4, pp. 2823-4.

became the keystone of Kiangnan Arsenal in 1865, was the biggest.[15] The Chinese merchants at this time did not have the capital and technical know-how to go into these kinds of business ventures. This was left in the hands of government officials who felt the responsibility to develop the kind of military industry which China needed so badly.

In the years 1862 and 1863, Li Hung-chang established three small prototype arsenals in Shanghai, all carrying the same name but headed by different people. One arsenal was directed by Halliday Macartney, and the other two by Han Tien-chia and Ting Jih-chang. In 1865, when the Kiangnan Arsenal was established, it not only bought equipment from the Thomas Hunt and Co. in Shanghai and Putnane and Co. in Fitchburg, Massachusetts,[16] but also absorbed two of the three small arsenals headed by Ting and Han. In the meantime, the arsenal headed by Halliday Macartney moved to Soochow in 1863, and then in 1865 became the Chin-ling Arsenal. The Chin-ling Arsenal was actually a branch of Kiangnan and eventually merged into the latter in 1906.

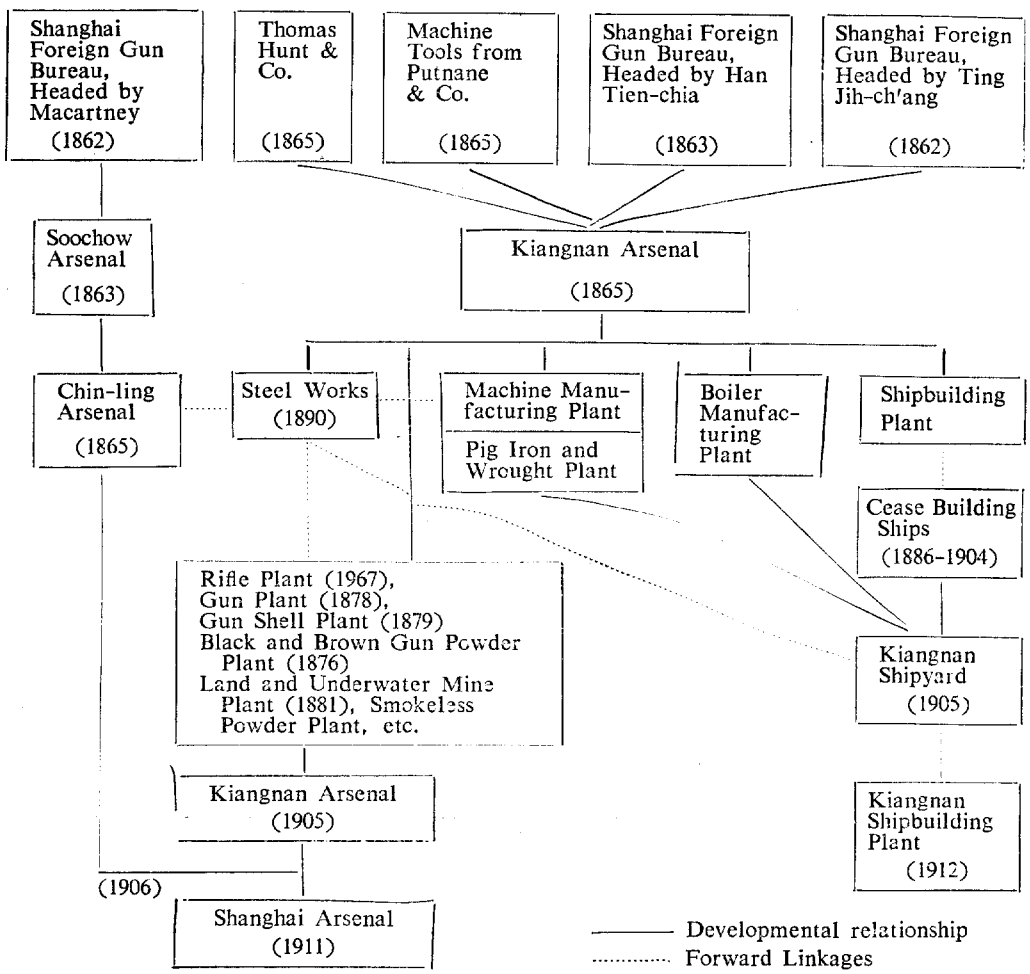
The total government investment in Kiangnan Arsenal from 1867 to 1904 was about 27,482,000 taels, and, in Chin-ling Arsenal from 1865 to 1906, was about 5,160,000 taels.[17] The investment of Kiangnan Arsenal alone was estimated at over 46% of the government total expenses on military arsenals throughout the country.[18] Thus, we can see its size and its strategic importance.

The Kiangnan Arsenal was basically a modern plant capable of producing machine tools, boilers, and ships, other than rifles, guns and ammunition. The early demonstrations of Kiangnan Arsenal in making machine tools and ships[19] had drawn applause from the foreign diplomats and journalists in China.[20] At the same time, it had strengthened the confidence of the Chinese officials.[21] It had to depend, however, entirely on foreign imported raw material and steel. It was not until 1890 that it started to install a small

(15) Sun Yu-t'ang, ed., *Chung-kuo chin-tai kung-yeh-shih tzu-liao* (Materials on the history of modern Chinese industry), series 1, v. 1 (1840-95), Peking: K'e-hsueh ch'u-pan-she, 1957, pp. 234-5.
(16) Yung Wing, *op. cit.*, pp. 90-98.
(17) Wang Erh-min, *Ch'ing-chi ping-kung-yeh te hsing-ch'i*, *op. cit.*, pp. 107-108.
(18) *Ibid.*, p. 148.
(19) Sun Yu-t'ang, *op. cit.*, series 1, v. 1, pp. 276-8.
(20) *Ibid.*, pp. 281, 288, 290.
(21) *Ibid.*, pp. 287-8.

Siemens-Martin blast furnace. And after years of experience and improvement, it was able to supply steel to meet the needs of ordnance production, naval construction, and other non-military uses. (22) We see a chance here that the steel works, the machine manufacturing plant, and the shipyard, together could have rendered steel, finished machine goods, and technical services, to other industries in the Shanghai area if they had been closely organized and planned. Unfortunately they failed to do so. The development and system of industries in Kiangsu province is shown in Table 1.

Table 1. The Evolution and System of Military Industries in Kiangsu.



(22) Thomas L. Kennedy, "The Kiangnan Arsenal in the Era of Reform, 1895-1911", *op. cit.*, pp. 328-330.

2. The Heavy Industrial System in Hupeh.

Unlike Kiangsu, the Hupeh industrial system, as mentioned earlier, was a self-sustaining one. The installation of Hanyang Ironworks, the investigations of iron ore and coal mines, the construction of an ore carrying railroad, and the establishment of Hanyang Arsenal, were started during the same period of the 1890's. In 1893, a railroad trackage manufacturing plant, a machine repair shop, and a metal manufacturing plant, were set up. They were ready to absorb pig iron and steel produced by the Ironworks. In 1896, Ping Hsiang coal mine was opened, consisting of many coke ovens, a brick manufacturing plans, a machine repair shop, a pig iron plant, and an iron casting shop. It supplied sufficient coke for the Ironworks and the Arsenal. By 1903, the Arsenal had its own steel refining plant, a machine shop, and a boiler manufacturing plant. A fireproof brick manufacturing factory was installed at Hanyang in 1903 to supply fireproof bricks for the Ironworks. In 1907, a cement factory with private capital was built at Ta-yeh, and a machine manufacturing company was established in Hanyang. This company drew equipment, capital, and managerial personnel, from the Ironworks. Its purpose was to build ships, construct bridges, make railroad wheels and trackage, and, most important of all, it planned to make machine tools. Thus, we can say that at the beginning of the 20th century, Hupeh had basically established a vertically integrated and self-contained industrial system with both forward and backward linkages as shown in Table 2.

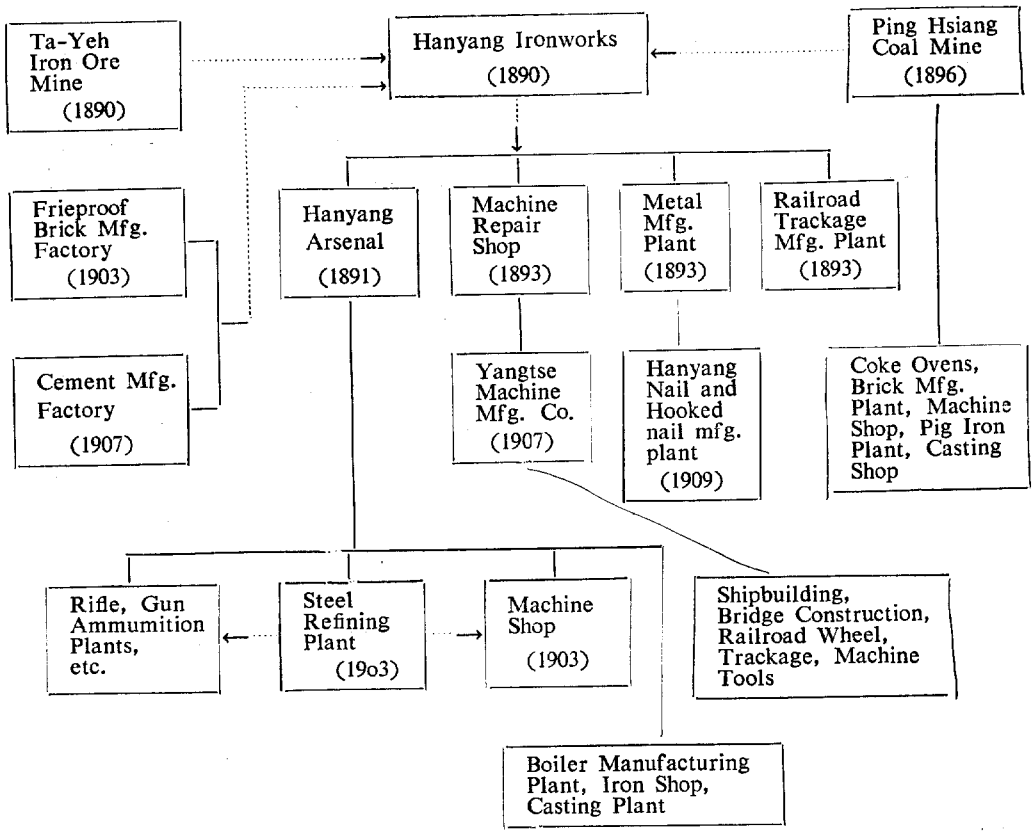
III. THE INDUSTRIAL MANAGEMENTS

From the functional point of view, a modern management should include: planning, organizing, staffing, direction, control, innovation and representation. (23)

What were the roles of these functions in China's early modern enterprises? We can be sure that there were no such things as innovation and representation in the early stages of China's industrialization. As to the rest of the functions, Chinese officials always tended to emphasize the aspect of power control and

(23) Ernest Dale, *Management: Theory and Practice*, N. Y.: McGraw-Hill Bk. Co., 1973, 3rd ed., pp. 4-7.

Table 2. Hupeh Heavy Industrial System.



neglect the important parts of planning, organizing, staffing and budget control. Since China's early modern enterprises were not privately owned properties, they could not be free of bureaucratic intervention. The general manager was not the final decision-maker in the enterprise. He must be subject to the Governor and the Governor-General for policy guidance, and they in turn must wait for the final approval of the central government.

In the process of planning, the Governor-Generals played even more important roles than the general-managers. However, the former were frequently incompetent, hasty, and piecemeal in the task of planning. For example, the Kiangnan Arsenal's additional machine tools were purchased from the United States. But the transaction was conducted by a Chinese

graduate of Yale who actually did not know what and where to buy. He then delegated his mission to an American mechanic who selected about 100 machine tools for the Kiangnan Arsenal without any idea of the Arsenal's original planning and present condition.(24) Moreover, for a long time the Kiangnan officials did not consider the technical manpower training and the development of domestic material resources as important tasks. Thus, the plant had to depend upon foreign engineers and technicians and imported raw material. The location of Kiangnan Arsenal was thousands of miles away from inland coal mines, and it was also vulnerable to foreign invasion. The relocation of the arsenal later became a great issue after the Sino-Japanese War in 1895.

As to the Hanyang Ironworks, its improper method of purchasing a plant, mentioned earlier, and its lack of market investigation and of financial and technical manpower at the beginning, are a well-known story. We need not reiterate it here.

Remaining to be discussed are the organizing function and the staffing function. We now judge the merit of an organization from two angles: one is its visible structure (or patterns), the other is its invisible spirit. The former stresses its clear cut hierarchical order and its effective horizontal connections; the latter emphasizes smooth vertical communication channel and the coordination and coorperation network.(25) In regard to staffing, a modern enterprise should emphasize"keeping the jobs filled with the right people".(26) The following analysis of the official enterprises in the two provinces is made from this point of view.

1. The Organizational Structures.

In 1868, John Fryer wrote to a publishing house in England, "The officials of the [Kiangnan] Arsenal are very anxious to obtain particulars and statistics respecting the management [and] working of the Arsenals in England……"(27)

(24) Yung Wing, *op. cit.*, pp. 90-98.

(25) Ch'en Ting-kuo, "Tsu-chi she-chi" (Organization planning), The Ministry of Edudation, ed., *Ch'i-yeh hsien-tai kuan-li chi-pen kuan-nien* (The basic concepts of modern enterprise management), Taipei; 1977, pp. 39-41.

(26) Ernest Dale, *op. cit.*, p. 356.

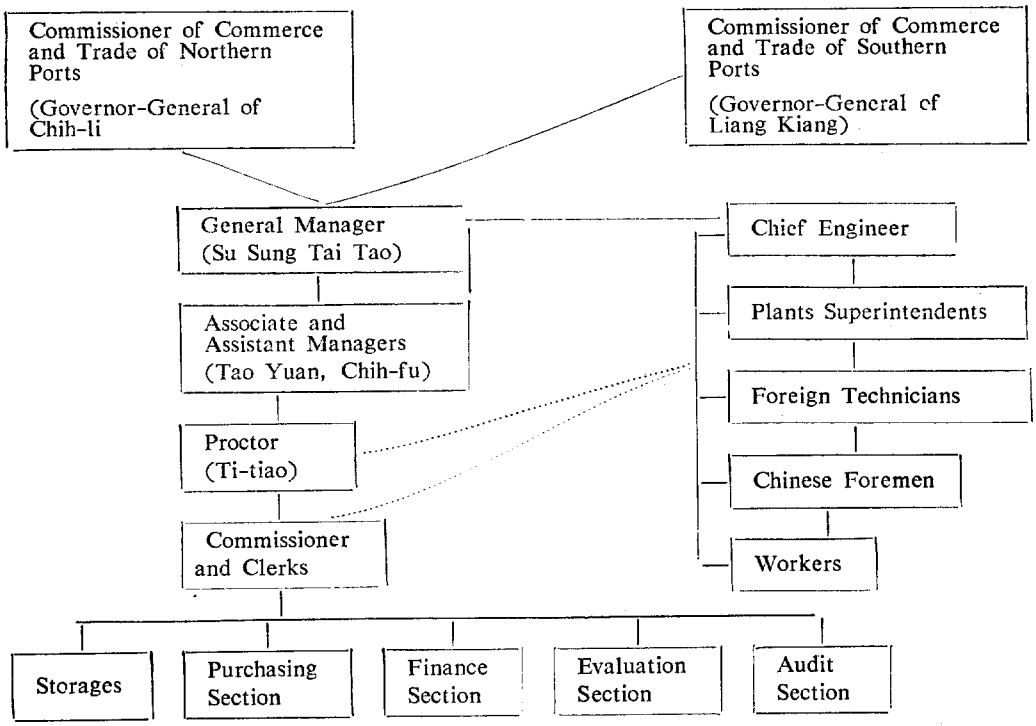
(27) Adrian Arthur Bennett, *John Fryer: The Introduction of Western Science and Technology into Nineteenth-Century China*, Cambridge: Harvard University Press, 1967, p. 29. From page 73 to 78 there is a list of materials ordered by John Fryer between 1868 and 1870, but it does not contain books on management.

We do not know whether John Fryer ever received the British management materials or not. But judging from the organizational structures of Kiangnan Arsenal and Hanyang Ironworks and other modern enterprises in Ch'ing China, we find out that there were some traces of imitation. For example, there was a division of managerial and technical departments. The technical department was headed by a chief foreign engineer who, in turn, had foreign engineers and technicians, and Chinese workers, under his command. He was authoritative in the realm of technology, but by contract, he was not permitted to intervene in matters of personnel, finance, and business srans-actions. The consultations between the two departments took place at different levels. This was the new system that transferred from the West. However, the management departments, though varied in different places, was basically a bureaucratic organization. Kiangnan Arsenal, for example, was directed by a group of officials ranking from general manager, associate manager, assistant manager, proctors (plant superintendent), and a large number of commissioners and clerks. The high ranking officials overlapped with each other, so that many people performed the same function. At the bottom of the organization structure, there was only a crude division of labor. There were purchasing, evaluation (of material prices), finance and audit sections and storages. In addition, there must also have been personnel, secretarial and general affairs sections, but there certainly were no technical training, employee relations, and research sections. Thus, the vertical control of Kiangnan Arsenal was overlapping, while the span of control was very narrow, as shown in Table 3.

However, when the Kiangnan Shipyard became independent in 1905, it followed the example of foreign enterprise and simplified its management personnel by doing away with the overlapping positions formerly held by the associate manager, assistant manager, and the proctors. And, at the same time, it increased the administrative power of the general manager, who personally took charge of the shipyard and was only responsible to the superintendent (the Admiral of Southern and Northern Ports).[28] In the tec-hnical department, it added a general supervisor to strengthen its technical service. In 1907, on a foreign engineer's suggestion, it went one step further

(28) Ch'en Chen, *op.* cit., series 3, v. 1, pp. 96-97. "The management regulation of Kiangnan Shipyard, 1905".

Table 3. The Organizational Structure of Kiangnan Arsenal (1865-1911)



to abolish the commissioner and clerk in th the plants. And adopted the Western foremen-workers system.[29] The effectiveness and achievement of this management reform can be seen in the increase in business volume and financial return, the amount of ships built and repaired, and shipyard expansion.[30]

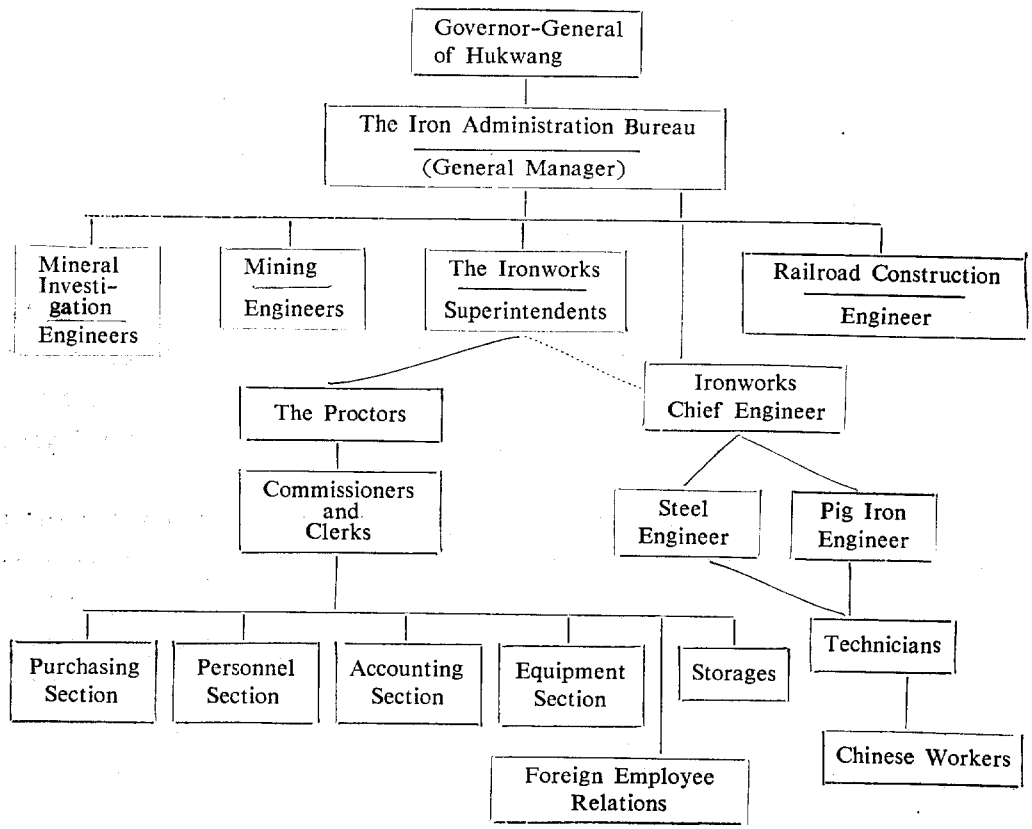
In Hupeh, the Iron Administration Bureau, in charge of all industrial affairs, was established in 1890. This office was headed by a general manager appointed by and responsible to the Governor-General of Hukwang. There were divisions of functions under it, such as mineral investigation, mining, railroad construction, arsenal, textile factories and the ironworks. Each division was staffed with foreign metallurgists, or engineers, and a Chinese superintendent who was of the magistrate rank and thus much lower than his counterpart in Kiangnan Arsenal.

(29) *Kiangnan Tsao-ch'uan-shih* (A history of Kiangnan shipbuilding), Shanghai: Hsing-hua Bk. Store, 1975, pp. 46-49.

(30) *Ibid.*, pp. 50-55. See also Thomas Kennedy, *op. cit.*, no. 3, pt. 1, pp. 324-325.

The management structure of Hanyang Ironworks seems to be a little simpler than Kiangnan Arsenal. The superintendent was the plant manager who, with the help of his subordinates, the proctor, commissioners, and clerks, took charge of personnel, accounting, raw material purchasing and storage, equipment and foreign employment relations. The technical department was headed by a chief engineer under the direction of a general manager. Beneath the chief engineer there were pig iron and steel sections which were under the charge of foreign engineers and staffed with foreign technicians and Chinese workers, as shown in Table 4.

Table 4. The Organization Structure of Hanyang Ironworks, (1890–1895)



Sources: Chang Chih-tung, *Chang wen-hsiang-kung ch'uan-chi* (The complete works of Chang Chih-tung), v. 1, p. 579; p. 2734. Sun Yu-t'ang, *Chung-kuo chin-tai kung-yeh shih tzu-liao*(Materials on the history of modern industry), series 1, v. 2, p. 783.

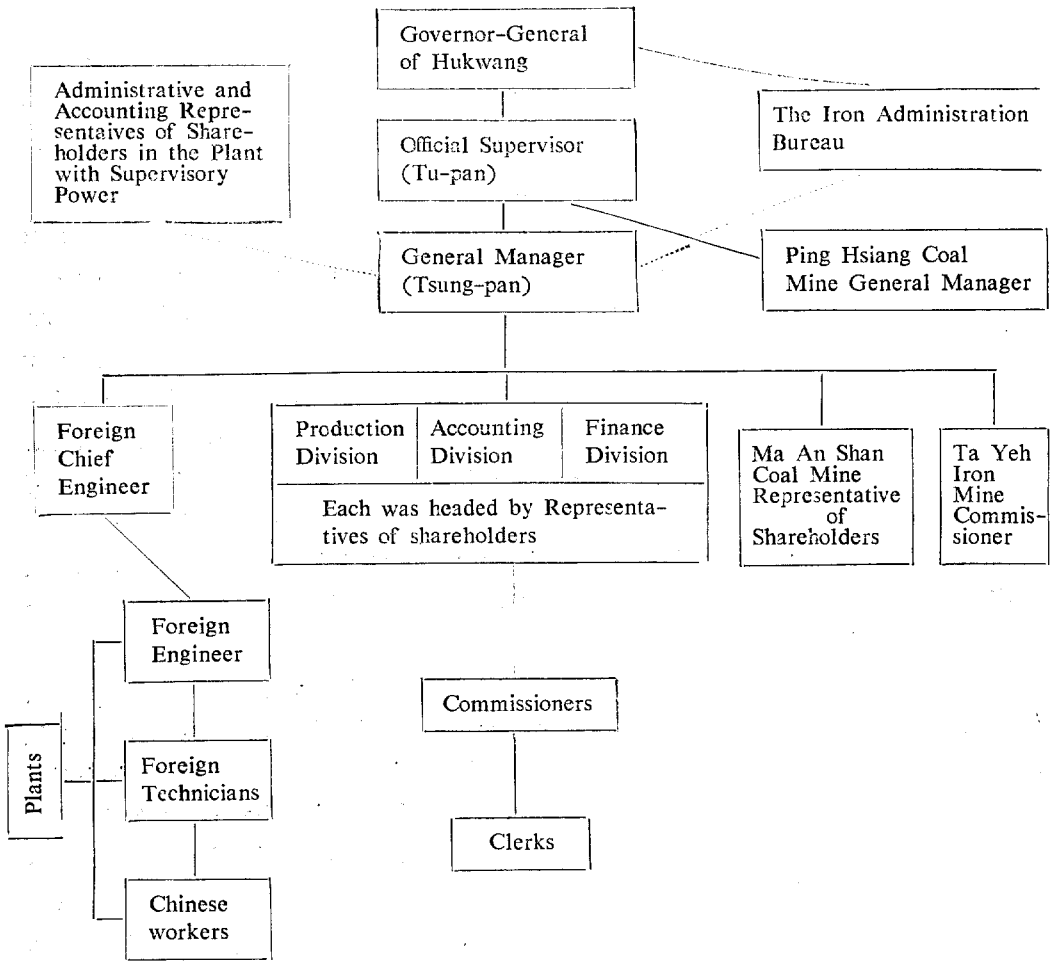
After the Hanyang Ironworks became an"official supervision and merchant management" enterprise (Kuan-tu shang-pan) in 1896, the organizational structure was said to follow the pattern of the China Merchants' Steamship Co. and the Telegraph Administration, only with a few differences. According to the proposal made by Chang Chih-tung in 1896, the organizational structure of Hanyang Ironworks became more complicated than before for two reasons: the increase of overlapping official supervisory power and the merchants' participation in mangement and supervision. Above the general manager, there was an official supervisor (Tu-pan) who was appointed by the Governor-General. The representatives of shareholders participated in different areas: one group supervising both administrative and accounting works, the other group in charge of the production, accounting and finance divisions. In addition, there was one shareholder representative in Ma An Shan coal mine. Thus, the organization was consistent in both theory and practice with the kuan-tu shang-pan format, and as shown in Table 5. However, in reality, another general manager was appointed to take charge of the Ping Hsiang Coal Mine when it was opened in 1896. The general manager at Ping Hsiang enjoyed more freedom of action than his counterpart at Hanyang due to his remoteness from the supervisor (Tupan) whose office was located in Shanghai. It was not until 1905 that the general manager at at Hanyang began to request more power in decision making.

Many scholars have been very critical of the Chinese management system. Feuerwerker has stated, "The kuan-tu shang-pan institution was deficient in the rationalized organization, functional specialization, and impersonal discipline associated with the development of modern industry in the West."(31) His statement is true in general. But when we compare the organizational structures of the two enterprises, we find that there many changes and differences over time and by place. First, they both adopted a technical department headed by foreign engineers. Secondly, the management structure was not rationalized in the case of Kiangnan Arsenal, but we have seen some specialization trend in the Hanyang Ironworks and the Hanyang Arsenal. Thirdly, the management reforms of Kiangnan Shipyard and Hanyang Ironworks after 1905 indicated that they were moving in a more modern direction. It was not until the end of the Ch'ing Dynasty that the merit of division of labor and specialization

(31) Albert Feuerwerker, *China's Early Industrialization, op. cit.*, p. 11.

was generally recognized and widely accepted in both business and government organizations.

Table 5. A proposed Organization Structure of Hanyang Ironworks. (1896)



Source: *Chang wen-hsiang-kung ch'uan-chi, op.cit.*, v. 2, p. 819.

2. The Recruitment of Managerial Staff.

"It is important to have a good organization structure, but it is still more important to fill the jobs with the right people",(32) especially for those

(32) Ernest Dale, *op. cit.*, p. 356.

who hold the strategic positions in the management department. As mentioned earlier that the organizational structures of both Kiangnan Arsenal and Hanyang Ironworks were not rationally planned. Therefore, the recruitment and selection of managerial personnel must be done with caution, otherwise the purposes of the organizations could not be achieved. How did they recruit their managerial staff?

The Kiangnan Arsenal recruited its managerial personnel from the following sources: 1) the secretarial offices of Tseng Kuo-fan and Li Hung-chang. These were the only places where most able proctors with knowledge of science and industry were selected. 2) Tseng, Li and other high ranking officials' relatives. This was the source from which most general-managers came. 3) Tseng Kuo-fan and Li Hung-chang's fellow countrymen from Hunan and Anhui. These were the major sources which provided most low ranking officials, such as commisssioners and clerks. (33) Of the two provinces, the Hunanese were more influential. (34)

In Hanyang Ironworks, nepotism and provincialism did not prevail in the beginning. There were also three sources of recruitment: 1) Chang Chih-tung's secretarial office. Tsai Hsi-yung, the general-manager of the Ironworks and other modern factories in Hupeh, was of this type. 2) Chang Chih-tung's subordinates in Hupeh. These were mostly degree holders but were selected for their abilities, not because of their family or provincial ties. Assistant managers, superintendents, commissioners and clerks were of this type. 3) Men with expertise in Western affiairs and industry, as Li Wei-ke, the general-manager of Hanyang Ironworks. Generally speaking, Chang Chih-tung seems to come closer to modernity in recruiting his managerial personnel. But when Sheng Hsuan-huai took over the enterprise, he practiced nepotism and provincialism. The appointment of Chang Tsan-ch'en as the General Manager of Ping Hsiang Coal Mines was said to be because of his native ties. And, worst of all, Sheng's relatives and friends were said to fill most middle and low positions on the staff. (35)

---

(33) *Kiangnan Tsao-ch'uan-shih, op. cit.*, p. 15.

(34) Thomas Kennedy, "The Kiangnan Arsenal in the Era of Reform", *op. cit.*, no. 3, pt. 1, p. 294.

(35) *Hanyehping kung-ssu tang-an* (Documents on Hanyehping Co.), held by Academia Sinica, no. C-2-5-5_2, "A Memorial Presented by the Minister of Industry and Commerce to President Yuan Shih-kai", Dec. 21, 1912.

In regard to education and experience, we see only a little difference between the two enterprises. The Kiangnan Arsenal in 1894 had over two hundred commissioners and clerks, and had accumulated thirty-two higher ranking management officials, from general-manager at the top to the proctors at the lowest level. Statistical data on educational background of the commissioners and clerks is lacking. However, they were mostly of traditional education and without knowledge or experience in industry and business.(36) This was the most ineffective and wasteful administrative section of the enterprise. As to the thirty two higher ranking officials, 41% of them had degrees of one kind or another, 3% came from military background, the rest are unknown. However, in the area of industrial knowledge and experiences, only 31% of the thirty two persons had industrial knowledge or experience, while 50% of them had no knowledge or experience in industry at all. The other 19% are unknown.(37) Thus we can say that most personnel in the Kiangnan management department were unfit for their jobs. The situation is even worse when we find out that those who filled the higher positions had less knowledge and experience in industry. The correlation rate between industrial experience and position was vertically spread from 8% on the top to 83% at the bottom as shown in the following table:

Ranks	Percentage 32 of persons with industrial knowledge or experience in each rank
general-managers	8
associate-managers	30
assistant-managers	33
proctors	83

Source: Hsieh Yen-keng, *op. cit.*, pp. 389-393.

In regard to managerial personnel in the Hanyang Ironworks, there is no statistical data like that of Kiangnan. However, the available literature can help us make a tentative conclusion that almost all positions below the general managers in both the ironworks and the coal mine were filled with people of

(36) Hsieh Yen-keng, *op. cit.*, pp. 403-405.
(37) Hsieh Yen-keng, *op. cit.*, pp. 389-393.

traditional education. They did not have knowledge or experience in indusrty. (38) But the positions of general managers were always filled with men of knowledge and ability. For examples, the first general manager of Hanyang Ironworks was Tsai Hsih-yung (-1897) fom Canton. He was a graduate of Canton Foreign Language School, had worked at the Chinese embassies in the United States and Latin America, and had travelled extensively in Europe. He was fully equipped with modern knowledge and was the important sponsor of Chang Chih-tung's many modern enterprises in Kwangtung and Hupeh. (39) The second general manager of Hanyang Ionworks was Li Wei-ke from Kiangsu. He was educated in England. In 1897, after returning to China, he had taught Western subjects at Shih-wu hsueh-t'ang (the School of Current Affairs) in Hunan. He had no personal tie with Chang Chih-tung or Sheng Hsuan-huai. (40) According to Chang Chih-tung, Li spoke well both English and French, and had studied manufacturing technology before he was invited to Hupeh. (41) The most striking fact is that neither Li Wei-ke nor Tsai Hsih-yung was a degree holder. The third general manager was Chang Tsan-ch'en (1864-1907) from Kiangsu, who held a Chien-Sheng degree. Obviously he was not western educated, but he was capable in handling industrial affairs, as we have seen in his "Report on the Development of Ping Hsiang Coal Mines", in 1904. (42) In view of the background of these three general managers, we can see that there was a great discrepancy between the chief executives and their subordinates in Hanyang Ironworks. The former had characteristics of modernity, while the latter tended to be conservative. The effectiveness of its management was therefore doubtful.

The managerial officials in Kiangnan Arsenal could not accumulate industrial experience because of their short tenures. Most general-managers were ready for extramural transfers or promotions and did not want to become professionals. Among 26 associate managers and assistant managers

(38) *Hanyehping kung-ssu tang-an, op. cit.*, no. C-2-5-7$_3$, "An investigation report presented to President Yuan Shih-k'ai by Tseng shu-ch'i", July 1914.

(39) Su Yun-feng, *Chang Chih-tung yu Hupeh chiao-yu kai-ke* (Chang Chih-tung and the educational reform in Hupeh). Nankang: Institute of Modern History, 1976, pp. 24, 39.

(40) Sheng Hsuan-huai, *Yu-chai tzun-kao* (Collected drafts of Sheng Hsuan-huai), ed. by Lu Ching-tuan, n. d., rptd. by Wen-hai Bk. Publisher, Taipei, 1963. Chuan 25, telegraph, p. 20. Letter from Chang to Sheng, Dec. 5, 1896.

(41) *Chang wen-hsiang-kung ch'uan-chi, op. cit.*, v. 2, p. 1093.

(42) *Hupeh Chien-ming kuan-tz'e* (A concise official gazette of Huph), Wuch'ang: 1908, Tao-yuan, p. 1; Ch'en Chen, *op. cit.*, series 3, v. 1, pp. 440-453.

from 1865-1904, 24 of them stayed on their jobs less than one year.(43) Therefore the accumulation of expertise was impossible. While at the lower levels, there was a surplus of unnecessary personnel. And yet there was no training program to train them or to fire them when they were unnecessary.(44) Unlike Kiangnan Arsenal, the tenures of all general managers in the Hanyang Ironworks and Ping Hsiang Coal Mine were very long. The average term of office was over nine years, and two of them died on their jobs. In fact, they had accumulated sufficient experience in modern enterprise. For example, Chang Chien, the famous Chinese entrepreneur and general manager of Hanyehping Co., said in 1915, that Li Wei-ke "was the only man who had experience in iron and steel manufacture in China today".(45) However, information on personnel training, promotion, and transfer below the general manager level in Hanyang Ironworks is unknown.

The ratio of personnel expense (labors and technicians excluded) to total expenditure of Kiangnan Arsenal increased from 17.8% in the first eight years to 22.2% in the next decade. Although the ratio in the following two decades dropped to 13.6% and 10.9% respectively, the real expenses were increasing. The cumulative expense for personnel from 1867 to 1904 was more than 3,250,000 taels which was close to 15% of the total expenditure of the Arsenal.(46)

The personnel and administrative expense of Hanyang Ironworks during the first 3 yeras (1890-1892) was 58,000 taels. This represented less than 2% of the total expenditures.(47) This personnel expense might have increased in later years, but we believe that the ceiling probably was not over 5% of the total expenditure. For example, the personnel and administration expenses of 1916 were 570,584 taels, which represented only 5% of the total expenditure of the Hanyehping Co.(48) Regarding the personnel and administrative cost of Hanyang Arsenal, during the 20 year period from 1890-1909, the Arsenal

(43) Hsieh Yen-keng, *op. cit.*, pp. 394-395.
(44) *Chang wen-hsiang-kung ch'uan-chi, op. cit.*, v. 4, p. 2746.
(45) *Hanyehping kung-ssu tang-an, op. cit.*, C-2-5-7$_4$, "Chang Chien's memorial to president Yuan through the Ministry of Agriculture and Commerce", Feb. 28, 1915.
(46) For expenditure between 1867 and 1894, see Sun Yu-t'ang, *op. cit.*, series 1, v. 1, p. 312; between 1895 and 1904, see Hseh Yen-keng, *op. cit.*, pp. 259-260.
(47) Ch'uan Han-sheng, *op. cit.*, pp. 34-35.
(48) "The 1916 account report of the 9th trustee of Hanyehping Co." in the *Hanyehping kung-ssu tang-an, op. cit.*, no. C-2-6-2$_4$.

expended a total of 725,000 taels in personnel and administration (again labor and technicians excluded). This occupied only 4% of the total expenditure of the Arsenal. (49)

In brief, there was a strong tendency of political intervention in modern enterprise management in Kiangnan, Hanyang, and elsewhere in China. Bureaucracy and red tape was characteristic. However, there were still many differences between these two firms. In recruitment of managerial staff, particularism prevailed in Kiangnan, while Hanyang tended to be more universalist. Expertise in industry could not be developed in Kiangnan because of short tenure and the extramural-promotion tendency. We can discern the emergence of professionalism in Hanyang, at least at the top executive level. The personnel and administrative expense in Kiangnan was larger and more wasteful than that of Hanyang. Thus we can conclude that the management of Hanyang, though not perfect, was probably better than that of Kiangnan.

IV. FOREIGN ENGINEERS & TECHNICIANS

With the foreign-made equipment logically came foreign engineers and technicians because there were hardly any Chinese at the time who had sufficient technical know-how to operate the machines then. The problem here was how to recruit foreigners, allot their duties, and make use of their knowledge. Indeed, it was a difficult task for there was no national policy or guiding regulations to follow. The provincial authorities were the individuals responsible for searching for and making contracts with foreign advisors. They recruited foreigners from among foreign missions, factories, shipyards and military men in China, through recommendations of Chinese embassies abroad or of factories where the equipment was purchased. The Kiangnan Arsenal in the early years mostly recruited its foreign technicians from the local scene. Hanyang Ironworks mostly recruited them directly from abroad. The expectations of Chinese officials were very high. They always wanted to enlist the best engineers and technicians, regardless of how much high they had to pay. But in fact, they were always disappointed, for the

(49) *Hupeh ping-kung kang-yao-ch'ang li-nien shou-chi ke-k'uan ssuchu ch'ing ch'e* (The four column accounts of Hanyang Arsenal, 1895-1909).

best they could get before 1905, were mostly of third grade. Sometimes they were deceived, since they did not have industrial kuowledge to make proper judgements. In the following pages I will compare the numbers, backgrounds, technical know-how, salaries, and work results of foreign personnel in the two provinces.

In number of persons, Hupeh employed more foreign engineers and technicians than did Kiangsu, because of the scale of its undertakings. From 1890–1909, Hanyang Ironworks and Arsenal enlisted more than 74 foreign advisors, (50) while Kiangnan and Chin-ling Arsenals employed about 44 persons during the years 1865 and 1911. (51) Most foreign advisors employed by the Kiangsu government worked at Kiangnan Arsenal, while in Hupeh they were largely concentrated at Hanyang Ironworks.

Table 6. An Incomplete Statistics on Nationalities of Foreigners at Kiangnan and Hanyang.

FACTORIES	Kiangnan Arsenal	Chin Ling Arsenal	Kiangnan Shipyard	Hanyang Ironworks	Hanyang Arsenal
PERIODS	1865-1905	1865-1885	1905-1911	1890-1897	1892-1909
British	13	2	15	13	
German			1	10	6
American	6*			1	
Belgian				40	
French	4*				
Japanese	1				2
Others	2				2
TOTAL	26	2	16	64	10
		44		74	

Sources: On Kiangnan, see Hsieh Yen-keng, *op. cit.*, pp. 396-400; and Ch'en Chen, *op. cit.*, series 3, v. 1, p. 98. On Han-yang, see Su Yun-feng, "Foreign Teachers and Advisors in Hupeh", op. cit., p. 52.

* These were missionaries who taught at the Foreign Language School of Kiangnan Arsenal. Statistics of foreigners at Hanyang, Ta-yeh and Ping Hsiang after 1897 were unavailable.

(50) Su Yun-feng, "Wai-kuo chuan-chia hsueh-che tzai Hupeh" (Foreign teachers and advisors in Hupeh), *Chung-hua wen-hua fu-hsing Yueh-k'an* (The Chinese Cultural Renaissance Monthly), v. 8, no. 4, April 1975, p. 52.

(51) Hsieh Yen-keng, *op. cit.*, pp. 396-400; Kennedy, *op. cit.*, pp. 292-293, 322; Ch'en Chen, *op. cit.*, series 3, v. 1, p. 98.

In terms of nationality, British advisors were more numerous than American, French and other nationalities combined in Kiangsu, while the Belgians ranked first in Hupeh, followed by Germans and British, as shown in Table 6.

The Chinese officials treated foreign advisors much better than did the Meiji Government.(52) Besides a high salary, it was stipulated in each contract that the advisor should also be provided with travel expense, additional allowance on the way back and forth, free housing, and medical care, etc. If he fulfilled his duty, or if he was discharged because of his poor performance, he would receive an additional three months salary on departing. If he died of illness on the job, his family would receive a compensation of six months salary. If he died from an accident, his family would receive a whole year's salary.(53) These stipulations, though not set up by the central government, were observed by all provincial authorities.

The average monthly salary range for engineers in Hupeh was from 400 to 700 taels, with one as high as 1,056 taels. For the technicians, the range was from 138 to 400 taels.(54) In Kiangnan Arsenal, the range was from 300 to 700 taels for the technicians,(55) with an exceptional high of 1,500 taels for the two British engineers in 1899.(56) In comparison, the Chinese received much less. The Chinese general manager of Kiangnan Arsenal got only 200 taels a month. The average wage of commissioners and clerks was then 27 taels.(57) A Chinese foreman got 7 taels, workers 3 taels.

The annual expense of foreign advisors, however, decreased due to policy changes in both provinces, although Hupeh continued to expend more on foreign advisors than Kiangsu. The average percentage of salary expense for foreign advisors at Kiangnan Arsenal during 1867 and 1889, with the exception

(52) Edward R. Beauchamp, *An American Teacher in Early Meiji Japan*, Hawaii: The University Press of Hawaii, 1976, p. 87. The average monthly salaries for foreign teachers in 1873 were ¥300-500, with some up to ¥600, while the president of Tokyo University then received about ¥400. The exchange rate between yuan and tael in 1901 was ¥1=0.71 tael, or 1 tael= ¥1.407. See Wang Shu-huai, *Keng-tzu p'ei-k'uang* (The Boxer indemnity), Nankang: Institute of Modern History, 1974, p. 48.

(53) Ch'en, chen, *op. cit.*, series 3, v. 1, pp. 244-245.

(54) Su Yun-feng, "Foreign teachers and advisors in Hupeh", *op. cit.*, v. 8, no. 4, p. 52.

(55) *Yang-wu yun-tung* (Documents on foreign affairs movement), Shanghai: Jen-min ch'u-pan she, 1961, v. 4, p. 81.

(56) Thomas Kennedy, "The Kiangnan Arsenal in the Era of Reform", op. cit., no. 3, pt. 1, p. 292.

(57) *Yang-wu yun-tung, op. cit.*, v. 4, p. 155

of 1876 and 1877, was estimated at 4.7% of the total expenditure. It was not excessive if compared with other cost. For example, the average personnel and administrative cost in the same period was 11.7%, and Chinese workers' wages 26.5%, as shown in Table 7.

Table 7. Cost of Salaries and Wages Paid by Kiangnan Arsenal to Foreign Engineers and Technicians, Chinese Commissioners and Clerks, and Chinese Workers, 1867-1889.

Year	Total Expenses of Kiangnan Arsenal (tael)	Percentage of Salaries for Foreign Advisors	Percentage of Salaries for Commissioners and Clerks	Percentage of Wages for Workers
1867-1873	2,236,224	6.3	5.0	
1874-1875	1,359,019	4.6	4.7	
1878-1879	796,808	5.8	9.7	
1880-1881	954,503	5.8	9.2	
1882	549,112	4.3	11.4	
1883	393,324	4.9	16.6	
1884	701,819	3.5	10.9	20.5
1885	375,328	5.3	19.0	31.2
1886-1887	931,556	3.8	16.1	29.2
1888-1889	1,032,273	2.6	14.2	25.2
Total & Average	9,328,966	4.7	11.6	26.5

Source: *Yang-wu yun-tung* (Documents on the foreign affairs movement), *op. cit.*, v. 4, pp. 31-72.

In Hupeh, the initial expense of foreign engineers and mechanics at the Ironworks was very high. It increased from 72,000 taels in 1890 to 144,000 taels in 1895. The total cost of foreign advisors in the first six years was estimated at several hundred thousand taels which, in turn, represented about 10% of the grand total expenditure.(58) This expenditure became a great burden and was thus reduced after 1896. At the Hanyang Arsenal, the expense of foreign technicians was rather moderate. During the year 1895 and 1909, the Arsenal spent a total of 415,000 taels, which only accounted

(58) For 1890, see Ch'uan Han-sheng, op. cit., pp. 36-37; 1895, see Chang Chih-tung, *op. cit.*, v. 2, p. 740, v. 4, p. 2824.

for about 2.5% of the total expenditure.[59] Thus, we can say that the cost of technical know-how of the Ironworks was much higher than that of the two Arsenals.

How much did China get in return? It depended upon the ability and sincerity of the foreign guests. Since information about backgrounds and work performance of foreign engineers and technicians in China is very scarce, we can not draw an accurate picture of them. However, scattered information put together could improve our understanding of them.

Among 44 foreign employees at Kiangnan and Chin-ling, there are only twelve persons whose background information is available, and eight of them were engineers.[60] However, except for Macartney and nine missionaries who taught languages and sciences at the Arsenal' Foreign Language School, we assume that most of the foreign employees might have received some sort of special training and factory experience. At Hanyang, there were seventeen engineers and 47 technicians. All had good training and extensive factory experience.[61] However, they were not the best that their countries could offer since their technical performace before 1905 in Kiangnan and Hanyang was always unsatisfactory. The causes of their poor demonstration at Kiangnan were said to be as follows: 1) They were mostly third rate technicians who could not design or make innovations. 2) The motives of their coming to China were self-interest, hardly any of them were sympathetic to Chinese industrialization. 3) The tenures of their contracts were very short, only 3 out of 27 persons stayed on their jobs for over three years. The average range of the rest was 1-2 years, some even less than a few months.[62]

In Hupeh, from the beginning foreign engineers of different nationalities were competing to control the mines and the Ironworks. As a result the Ironworks changed into different hands, first British, then Belgian and German.[63]

Technically, the foreigners had to help the Hupeh Government open

(59) *Hupeh ping-kung kang-yao-ch'ang li-nien shou-chi ke-kuan ssu-chu ch'ing ch'e, op. cit.*
(60) They were Stephenson, Bunt, Cornish, J. M. Allen, Basse (German), R. B. Mauchan (British), and two other unknown British engineers.
(61) Su Yun-feng, "Foreign teachers and advisors in Hupeh", *op. cit.*, pp. 52-53, 59-61.
(62) Hsieh Yen-keng, *op. cit.*, pp. 395-405.
(63) Su Yun-feng, *op. cit.*, p. 54.

mines, install the Ironworks, and build a railroad for the transportation of iron ore. But they were technically impotent in two important areas. The first was in the chemical analysis of Ta-yeh iron ore, the second was in the problem of energy resourses. These errors had caused a great deal of difficulty for the Ironworks. We know today that the Bessemer Process furnace could not produce good steel from iron ore consisting of over 2.5% of phosphorus. (64) But the British chemist Robinson reported in 1890 that the Ta-yeh iron ore consisted less 0.08% of phosphorus. Other engineers did not see his error and agreed that the Bessemer process would be workable. (65) As a result the steel that came out of this process was very brittle.

In the search for fuel resources, all mining engineers reported in 1890 after an extensive survey that there were more than twenty potential coal mines in Hunan and Hupeh, with coal that could be converted into good coke since they consisted of less than 10% of undesirable sulphur and dust. On their suggestion, Chang Chih-tung invested more than 500,000 taels on two coal mines in Hupeh, but without any encouraging results. The Belgian chief mining engineer reported that the quality of the coal was even better than that of the Ping Hsiang coal mine. It was not until 1896 that this mistake was discovered by two German engineers. (66) And yet the error of iron ore analysis was carried on until 1904 when Li Wei-ke, the general manager, was on a business trip to Europe asking for another British chemist to reexamine the iron ore samples he brought with him. (67)

The tension between Chinese officials and the foreign advisors in Hupeh was very high. Conflicts occurred from time to time, possibly because of the cultural gap, misunderstanding or malice. The Chinese officials needed their help but were always suspicious of their sincerity and intentions. As mentioned earlier, many of them were indeed aggressive. Some were arrogant in manner, (68) the others were alcoholic. (69) When the Belgian engineer was discharged by Chang Chih-tung because of his poor performance, he asked

(64) Ch'uan Han-sheng, *op. cit.*, pp. 55-56.
(65) Chang Chih-tung, *op. cit.*, v. 4, p. 2509, "Telegraphs to Ambassador Hsuch in London", Oct. 21, 1890 and Nov. 2, 1890.
(66) Su Yun-feng, *op. cit.*, p. 57.
(67) Ch'en Chen, *op. cit.*, series 3, v. 1, pp. 407-417.
(68) Chang Chih-tung, *op. cit.*, v. 4, p. 2734.
(69) *Ibid.*, v. 4, p. 2907.

for a diplomatic intervention. (70) Or if pressed by Chinese officials, they would threaten to shut down the factory.

In conclusion, there are four major characteristics of the foreign technical personnel in Kiangsu and Hupeh: 1) They had special training and factory experience, but they were mostly technician. Only about two dozen of them could be classified as third grade engineers. They fulfilled some of their mission, but were unable to solve many other important technical problems. 2) The foreign engineers invited by the two provinces after 1905, though reduced in number, were of better quality than those employed before. 3) The total expense on purchasing technical know-how in Hupeh was higher than in Kiangsu. However, it did not represent a great portion of the grand total expenditure, if compared with other expenses. 4) The employment relations in the two provinces were different. At Kiangnan Arsenal, relations between Chinese and foreigners were harmonious and cooperative, but they were hostile in Hanyang. Officials at Kiangnan tended to surrender their power to foreign engineers, who then had more freedom to interfere with the purchasing and administrative affairs of the management department. While in Hupeh, the foreign guests' motives, for better or for worse, were constantly checked and blocked by the Chinese officials. Neither cases produced good results, because of the technical insufficiency and selfishness of the foreign employees, on the one hand, and the incapability of Chinese officials to utilize what they had brought to China, on the other hand. Besides, the officials did not realize or were reluctant to recognize the importance of scientific and industrial education, which will be discussed in the next section.

V. MEASURES FOR TECHNOLOGY TRANSFER

When we discuss technology transfer, we should pay attention to the fact that it involves an intensive teaching and learning process between teachers or engineers from developed countries and students or workers of an underdeveloped nation. The transfer process may take place at schools or in factories, at home or abroad. To guarantee its success, an educational reform is

(70) *Ibid.*, v. 4, pp. 2907-2908.

necessary, and special emphasis should be put upon industrial education.

Although the Chinese officials had time and again expressed their concerns over the problem of technology transfer, (71) they did not have enough wisdom and courage to breakthrough the ideological and institutional barriers. The first was the civil service examination system which absorbed all the young intellectuals who wanted to enter officialdom. Before its abolition in 1905, a sound modern education could not be developed. The second was a long time social value that respected men of book learning, and despised those who worked with labor and skills. This is why Tseng Kuo-fan and Li Hung-chang were able to establish the Kiangnan Foreign Language School in 1863 and the Translation Office in 1868, but failed to initiate a training program for the Chinese workers. Nor were they able to develop a program for engineer training.

As early as in 1867, Yung Wing had proposed to Tseng Kuo-fan, who was then visiting the Kiangnan Arsenal, that a mechanics school be attached to the Arsenal "in order to teach Chinese youths the theory and practice of mechanical engineering and allow China to be eventually independent of Western mechanical engineers and machinists." (72) Tseng was said to be moved by Yung's proposal, but he did not respond before his death in 1872.

In 1874, the Arsenal began to establish a technical school, but this was far away from Yung's expectations. It was first called the "Gunnery School", then renamed "The Gunnery Battalion" in 1881. In addition, a mechanical drawing class was opened around 1880's. However, these schools were limited in scope and depth, and they enlisted only a few young men. Their curriculum "did not include the thorough grounding in the principles of modern technology necessary for the development of new systems of production". (73) And to John Fryer's disappointment, they even seldom used the books on science and technology translated by him for the Kiangnan Translation Office. (74)

---

(71) Lu Shih-ch'iang, *Ting Jih-ch'ang yu tsu-ch'iang yun-tung* (Ting Jih-ch'ang and the Self-strengthening movement), Nankang: Institute of Modern History, 1972, p. 50; Kuo T'ing-yee and others, ed., *Kuo Sung-t'ao Hsien-sheng nien-pu* (A chronological biography of Kuo Sung-t'ao), Nankang: Institute of Modern History, 1971, pp. 620-621, etc.

(72) Adrian Arthur Bennett, *John Fryer*, op. cit., pp. 19-20.

(73) Thomas Kennedy, "The Kiangnan Arsenal in the Era of Reform", *op. cit.*, no. 3, pt. 1, pp. 277.

(74) Adrian Arthur Bennett *John Fryer, op. cit.*, pp. 40-41.

After the Sino-Japanese war in 1894, pressure for educational reform became stronger. In 1898 the Kiangnan Arsenal followed the example of the Osaka Technical School in Japan and merged the Gunnery Battalion and the Mechanical Drawing Class into the "Polytechnic School", which consisted of a chemical engineering division and a mechanical engineering division. A four-year course on science and technology was offered to a group of 50 students. But for the moment, no foreign teachers were invited, (75) possibly because of a lack of money. In 1902, some students were sent to Japan for training, but their quality was questionable. (76) In 1905, the Polytechnic School was again merged with the Foreign Language School to become the "Industrial School", which was basically an ordnance school in reality. It consisted of four levels: the apprentice school, the ordnance primary school, the ordnance middle school, and the ordnance college. (77)

In short, the self-strengthening movement between 1862 and 1894 is designated as a period of "technical innovation" by historians today, but the hard fact is, as we found here, that the Kiangnan Arsenal simply sat idle for more than thirty three years, doing nothing in the area of technical manpower training. The training program after 1898 was better organized, though, it was still limited in size and scope. It produced hardly any significant result.

In Hupeh, technical education was considered important from the beginning, for Chang Chih-tung not only expressed his desire to train apprentices, technicians and engineers, but also actually tried time and again to do it.

In 1890, Chang Chih-tung first allocated 30,000 taels for the establishment and maintenance of a mineral school and a chemical school on a temporary two year basis. Foreign teachers were employed, and dozen of students were recruited from Shanghai and Fukien. After a short term training, they were sent out to join the mineral investigation team working in the field. However, the mineral school stopped functioning after a while, and the chemical school was merged into another school in 1896 due to general indifference to the technical professions. (78)

---

(75) Sun Yu-t'ang, *op. cit.*, series 1, v. 1. pp. 88-89.
(76) Thomas Kennedy, *op. cit.*, no. 3, pt. 1, pp. 293-294.
(77) Sun Tsu-heh, *Ch'ing Tai T'ung-wen-kuan chi yen-chiu* (A study of Foreign Language Schools in the Ch'ing Dynasty), Taipei: Chia-hsing Shui-ni Kung-ssu, 1977, pt. 313.
(78) Su Yun-feng, *Chang Chih-tung and Educational Reform in Hupeh, op. cit.*, p. 144.

In 1898, Chang established a polytechnic school at the capital city of Hupeh, with two goals in mind: one was to cultivate engineers, the other was to train technicians. But events went contrary to his expectation, and no youths responded to his call at the first entrance examination. He was forced to abandon, at least temporarily, his high hopes of educating engineers, and opened courses for technician training only. (79)

In 1902, at the time of his promulgation of the Hupeh school system, Chang announced that the polytechnic school would be expanded and raised to college level. The new school consisted of five departments: physics and chemistry, mechanics, manufacturing, textile engineering, and civil engineering. A four-year curriculum was offered to about sixty students. Certificates in engineering would be given to them upon their graduation. Furthermore, an apprentice class with thirty students was added to the school. Evidence shows that the new polytechnic school progressed slowly in the first four years due to mismanagement, but improved after 1905. (80)

Meanwhile in 1899, Chang requested Sheng Hsuan-huai to establish a steel engineering school in Hupeh in order to supply technicians for the Ironworks. But Sheng disregarded his proposal, and thus Chang's plan did not materialize. (81)

In regard to worker training, Chang also confronted difficulties. We know that there were about two to three thousand workers in Hanyang Ironworks. But most skilled workmen were recruited from Canton or Shanghai. Although they had factory experience, they still needed training. In 1890, Chang planned to send 50 young workers and apprentices to England to learn metallurgical technique for a half year, and twenty men to a German Arsenal for six months of factory training. But he was dissuade by the Chinese Ambassador in Germany from doing so. (82) However, two years later he persisted in allocating 20,000 taels for sending 40 workers in four instalments to Belgium for one year factory training. (83) By 1894, twenty of them had returned and worked as assistant technicians under the

(79) *Ibid.*, pp. 143-149.
(80) *Ibid.*
(81) Sheng Hsuan-huai, *Yu-chai Tzun-kao, op. cit.*, chuan 34, telegraphs 11, p. 29, telegraph from Chang Chih-tung, dated Dec. 12, 1899.
(82) Chang Chih-tung, *op. cit.*, v. 4, p. 2506.
(83) *Ibid.*, v. 3, pp. 1800-1801.

Belgians.(84) But the technology transfer still did not take place, because the Belgian technicians did not like to teach the Chinese workers.

In brief, the investment in technical manpower training by both Kiangsu and Hupeh was very small. However, it seems that Hupeh officials were much more serious about training higher level technical manpower than Kiangnan officials were. As Professor Kennedy put it, in Kiangnan, "the technical training of domestic personnel had been almost entirely neglected" before 1895.(85) Training programs moved ahead a little after 1898, but what the Kiangnan officials perceived of industrial education was essentially an ordnance technical training. In Hupeh, Chang Chih-tung was always eager to train engineers and technicians. But he failed to achieve his goals either, because of the conservative intellectual climate, because of Sheng Hsuan-huai's indifference and because of Chang's own hesitation to invest more money.

CONCLUSION

The government's role in China's early industrialization had been increasingly important since 1865.(86) However, the initiatives in promoting industry were in the hands of the provincial authorities. A country like China, with so vast an expanse of land, dense population, poor agricultural economy, and rich but virtually undeveloped natural resources, needed more efforts in central planning, direction, coordination, cooperation, and policy control. Thus the weakness of the central government, although allowing more freedom to local initative and innovations, inevitably also led to many difficulties. First, no persistence of industrial policies could be maintained. They were subjected to sudden change just by a change of leadership, as in the cases of Foochow Shipyard,(87) Kiangnan Arsenal and Kiangnan Shipyard. Secondly, no reasonable allocation of scarce resouces of finance and managerial manpower was possible. Thirdly, inter-regional political rivalries could

(84) *Ibid.*, v. 1, p. 656.
(85) Thomas Kennedy, *op. cit.*, no. 3, pt. 1, p. 292.
(86) Albert Feuerwerker, *China's Early Industrialization, op. cit.*, p. 9.
(87) Chang Yu-fa, "Foochow ch'uan-ch'ang chi k'ai-ch'uang chih-ch'i ch'u-ch'i fa-chan" (The establishment and early development of Foochow Shipyard), *Bulletin of the Institute of Modern History*, no. 2, 1971, pp. 190-193, 223.

not be avoided, and, in turn, the rivals reduced or even destroyed each other's efforts at industrial undertakings, as in the cases between Tso Tsung-t'ang of Foochow Shipyard and Li Hung-chang of Kiangnan Arsenal before 1874, (88) and between Li Hung-chang and Chang Chih-tung after 1890.

The important cause which led to different industrial development in Kiangsu & Hupeh was essentially the different perceptions of industrialization between Li Hung-chang and Chang Chih-tung. Li's decision to establish the Kiangnan Arsenal definitely set the direction to a military and shipbuilding industrial system in Kiangsu regardless of what policy changes had been brought about due to the leadership changes mentioned earlier. The same effect was also true of Chang Chih-tung's hasty decision of purchasing an ironworks on the heavy industrial system in Hupeh. For when a decision was made, and vast sums of money had been invested, it became a political burden that could not be stopped.

The problem of industrialization of modern China can be narrowed down to a problem of technology transfer. A successful technology transfer should involve a correct policy, good planning, effective management and sufficient technical manpower. In terms of policy making, Li Hung-chang might have been right, because he knew that he could not do more than concentrate on military industry, without which the Ch'ing government could not survive. Chang Chih-tung was apparently mistaken since he had chosen the tremendously difficult course: heavy industry plus light industry at the same time, for which China had no sufficient capital to support. It inevitably led to borrowing foreign debts on unequal terms. In industrial planning, both Kiangnan and Hanyang were hasty and piecemeal, if compared to the planning of Foochow Shipyard in 1866. (89) Both Li Hung-chang and Chang Chih-tung were over confident in their ability to industrialize China. However, they did not realize the complexity and difficulty of modern technology. Their ignorance led to insufficient technical manpower training. In modern enterprise management, both Kiangnan and Hanyang had adopted a Western technical department, but were unwilling to accept a rationalized structure and function. The omnipotence of politics over professionalism and specialization had weakened the role of the two governments as modern entrepren-

(88) *Ibid.*, pp. 223-224.
(89) *Ibid.*, pp. 178--190.

eurs. It was not until 1905 that the general manager of Hanyang Ironworks requested an integrated power of action, and the Kiangnan Shipyard authorities surrendered, though unwillingly, their power to a capable and responsible foreign engineer. Only then could management effectiveness be achieved. (90)

What was the role of foreign engineers and technicians in China's early industrialization? The answer is: it was not a satisfactory one. The reasons are many: First, before 1905, they were mostly technicians who could not design or solve highly technical problems, although those employed by Hupeh were better qualified than those employed by Kiangnan. Second, there were no similar restrictions in the contract madee by Foochow Shipyard in 1866 to guarantee the technology transfer within a certain period. (91) Foreign engineers and techicians at Kiangnan and Hanyang actually did not want to pass on their technical know-how to Chinese workers. Third, they conflicted with each other, as in the case of Hanyang Ironworks, and this certainly reduced their offorts to help China's industrialization.

The self-strengthening movement has been designated by historians as a movement of technical imitation from the West. So that we imagine the technical manpower training should have been the most important priority in Kiangnan's industrialization efforts. Unfortunately, Kiangnan officials entirely ignored this problem before 1898. Thereafter, they began to realize its necessity but only tried in a very limited scope. Hupeh had paid a little more attention to the training program, though, it was still not an impressive one. The causes of failure to make an energetic training program are two: First, there were institutional and ideological barriers that no provincial authority could breakthrough. Second, out of ignorance or unwillingness, they were not prepared to invest more money in it. Here I would not hesitate to agree with Professor Feuerwerker's conclusion on his study of China's early industrialization that "one institutional breakthrough is worth a dozen textile mills or shipping companies established within the framework of the traditional society and its system of values ". (92) Furthermore, I would add that if equal amounts of money had been invested in a good technical manpower

(90) *Kiangnan Tsao-ch'uan-shih, op. cit.*, pp. 43-49.
(91) *Ibid.*, p. 186.
(92) Albert Feuerwerker, *op. cit.*, p. 242.

training program, it would have brought China closer to industrialization than did the Kiangnan Arsenal and Hanyang Ironworks