

Technological Innovation and the Development of Transportation in Japan

Edited by
Hirofumi Yamamoto



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The United Nations University project on Technology Transfer, Transformation, and Development: The Japanese Experience was carried out from 1978 to 1982. Its objective was to contribute to an understanding of the process of technological development in Japan as a case-study. The project enquired into the infrastructure of technology, human resources development, and social and economic conditions and analysed the problems of technology transfer, transformation, and development from the time of the Meiji Restoration to the present. The research was undertaken by more than 120 Japanese specialists and covered a wide range of subjects, including iron and steel, transportation, textiles, mining, financial institutions, rural and urban society, small industry, the female labour force, education, and technology policy.

This volume examines the development of transportation in Japan from 1867 up to 1980.

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Foreword

This book is a product of a research project on development and technology that the United Nations University (UNU) entrusted to the Institute of Developing Economies (IDE), Tokyo. This project on the Japanese experience, which achieved its industrial revolution by transferring technology from industrialized countries, was designed at the very beginning to include the issues of transportation technology.

In addition to such civil engineering aspects as surveying and bridge-building, railroads are vast modern systems of great complexity and precision that also embrace such components as the design, manufacture, and repair of rails, roadbed, and rolling-stock and the operation of equipment, communication devices, and stations. Railroads are also inseparably linked with such other industrial technologies as those for the supply of water, coal, and electricity. It is thus that the railroads can be used as an index in testing and evaluating the content and standards of a country's entire technological system.

Although the "Black Ships" of Commodore Matthew C. Perry symbolized to the Japanese the terrors of the modern era, the railroads provided the conveniences and prosperities closest at hand of what came to be known as the "flowering of civilization." That was what attracted the dreams of youth and what made the young Togo Heihachiro (the future admiral) want to be an engineer of railroads.

The role played by the railroads in the history of modern Japan's technological development is as important as that of shipbuilding, steel production, mining, or textiles. Special attention should be given to the effect that the railroads' machinery and equipment sections had in the development and modernization of the metal and machine industries throughout the country. The city of Hamamatsu is the first example of a so-called technopolis, an urban area in which are concentrated many industries using advanced technologies. Although the area's industrial history includes wood-working and textiles, the modern musical instruments, electrical equipment,

and motor cycle industries there would not exist if it had not been for the stimulus provided by the railroads' machinery and equipment departments.

Technology that has as its basic character the construction of regional networks, as railroad technology does, must be conceived as something that extends uniformly over the nation. It must be implemented as part of government policy, but must also be backed by national consensus: the support of the entire nation.

Moreover, because it was the "age of railroad imperialism" that first opened Japan's eyes to the railroads, the development of policy in regard to railroads has significance for all problems of technology from the viewpoint of advantages and disadvantages to a nation's citizens. Its meaning is as decisive to subsequent technological progress as the law that forbade foreigners from mining Japan's underground raw materials.

Government-constructed and -operated railroads were the ideal of the new technocrats, an ideal that was eventually frustrated (except for countries that Japan colonized, where it did achieve high technical levels). However, the railroad bureaucracy's unification of standards nationwide wrought enormous economic and social benefit. This can be confirmed simply through a comparison with the history of railroad development in India.

Similarly, the question as to whether we can cleanly divide the periods of contemporary transportation history and say that the railroad era has ended and that we are now in the era of motor vehicles is probably best answered by examples from those developing countries that have made motor vehicles the pinion of their post-World War II transportation policy and are now grappling to introduce interurban and underground railways.

Discussions in the industrialized countries claiming that the sun has already set on the railroads are rebutted by such systematic concentrations of advanced technology as the Shinkansen (lit., New Trunk Line; often referred to as "bullet train") that reconfirm the railroad's functions both old and new. However, these developments are confined for the time being to passenger transport, even though the railroads still have the potential to carry large amounts of freight. We could of course achieve even greater economies of scale through the use of large ship transport.

When I hear discussions on transport and communication by third world scholars and those involved in the practical aspects of development, I recall that in Japan's case the preconditions for development had been laid hundreds of years before. The feudal governments of shogun and *daimyo* (feudal baron) had constructed a network of five main highways and many other large and small roads connecting all of Honshu. The only thing technology-transfer-induced modernization did was to widen the roads and make them passable in all kinds of weather and at any time of the year. Oliver Statler presents an excellent case-study of road management and amenities in his *Japanese Inn* (1961).

All those interested in Japan's transportation problems will want to turn their attention also to river transportation, where a once splendid network of boat transport flourished and now only the local company names re-

main. One example of how important boat transport was is seen in all of Tokyo's major freight stations, which were built in the same places as terminals for barge transport.

The US forces occupying Japan after World War II were flabbergasted at the horrendous state of the roads, but those roads had by no means been built for motor vehicle traffic. As Professor Yamamoto points out, this lack of good roads was a result of Japan's approach to dealing with a situation where there had been no era of transportation by horse-drawn vehicle, and the modernization of roads took place as part of the attempt to modernize all transport, including rail and water, at one time.

One of the features of modernization in its initial stage was the mixed nature of transportation, what Yamamoto calls a patchwork system. At the beginning of the period of modernization, the only way the long-distance traveller could get to his destination was through a combination of horse-back, boat, and shank's mare. The addition of the railroads made travel faster and their ability to transport large volumes of passengers and goods eventually made possible a railroad-linked transport system. However, one must remember that the road network had yet to be built.

One of the features of mixed transport in the initial period of modernization is seen in urban transport, where appeared rickshaw, horse-drawn cart, and horse-drawn railway in a span of a little more than 10 years. Each of these was the newest development in transportation technology and was an answer to a wide range of needs. Through changes in the source of energy, horse-drawn railroads were replaced by trams and rickshaws and horse-drawn carts were replaced by bicycles and motor vehicles.

Partial electrification in 1909 of Tokyo's Yamanote (loop) Line, the prototype of modern urban transport, and completion of this transit loop in 1925 were the fruits of Japan's first period of self-reliance in industrial technology. However, this was still the railroad era and it would be more than 40 years, with the Second World War intervening, until the second road (motor vehicle) era.

At the beginning of the 1960s, I stared in wonder when I first saw the magnificent colonial roads of Asia. The changes in Japanese transportation problems during the last quarter of a century have again clarified the differences and similarities in content in our mutual problems of development and transport. The 1984 general conference of the United Nations organization ESCAP, held in Tokyo, assigned stages to the next 10 years in the problems of development and transportation-communications.

The work of the IDE-UNU research group should provide grist for the mills of the North-South debate on development and some assistance in getting that debate on track. But that also places some obligations on the authors. It was due to their efforts that this book is of a type never before seen in scholarly works. It is the first to encompass the more than 120-year history of networks and policies in modern Japan's transportation. The book is a joint academic effort that could only have been completed by scholars who are authorities in the history of transportation, geography, the history

of technology, and highway engineering, a cooperative effort totally unprecedented in Japan. The coordinator was unable to include the work of Ichiro Ishii because of its highly specialized nature as an engineering work, but much of the essence is contained here in the other authors' contributions, although in a much simplified fashion. I would like to thank Professor Ishii and the authors for their efforts.

The absence in this book of a comprehensive treatment of the issues of aircraft and airlines may appear to constitute an important omission, and this is one area in which Japan is said to have insufficient technical competitiveness (particularly in large planes). However, it is an area that is inseparable from the development of military technology, which is outside our realm of interest, and for that reason, leaving these issues out presents no obstacles to a project such as this that has focused on development and technology, and gaining self-reliance in technology for national development.

The efforts of Hirokazu Tada, Akiko Akemine, and other of my colleagues are greatly appreciated. I would also like to thank Takeo Uchida of the United Nations University and Shigeo Minowa, formerly of the UNU, for everything they have done.

Takeshi Hayashi
Project Coordinator

Preface

This book presents the results of research by the study group on Japanese transportation, part of the Project on Technology Transfer, Transformation, and Development: The Japanese Experience, a survey research project entrusted to the Institute of Developing Economies by the United Nations University. After completing preparations in 1977, the study group officially began work in April 1978. The study group's five members were Eiichi Aoki of Tokyo Gakugei University; Ichiro Ishii of Toyo University; Katsumasa Harada of Wako University; Hiromi Masuda of Bunkyo University; and myself. I was group leader, a post that gave me the duties of organizing all research. The group met on the first Tuesday of every month at IDE, where they were also able to be in direct liaison with the IDE-UNU project team. The historical period under study was originally from the beginning of the 1860s to around 1900, although our framework changed as research progressed. Reports were turned in sequentially. Research was divided according to the particular specialty of each scholar. Road transportation was handled by me, road construction by Professor Ishii, river and coastal shipping by Professor Masuda, and railroads by Professors Aoki and Harada. By October 1978, each member had submitted a 50-page interim report in Japanese. The reports were published in Japanese and subsequently in English by the UNU between 1979 and 1982. In 1986, the UNU published the Japanese edition of which the present book is a translation.

The latter part of the nineteenth century was one in which Japanese on every level felt themselves under pressure from the West as they strove to bring Japanese levels of technology up to those in the West. The nation sought to introduce, acquire, improve, and develop advanced technology in every field, things as well as systems. Transportation was of course no exception. One after another, transportation means that were already in use in the West, and may have even become obsolete there, were brought into Japan: horse-drawn carriage and railway, Western sailing-ship, steam locomotive, and steamship. With government subsidies concentrated on

railroads and Western shipping, Western means of transportation, old and new, sometimes competed and at other times supplemented each other, until by the year 1900 a modern transportation system was established centred on the railroad and steamship. The above-mentioned reports dealt chiefly with the introduction of advanced technology during the industrial revolution of that time. They discussed the distinctive features of Meiji government industrialization policy, and the process by which technology was improved and developed and technological independence was gained in land and water transportation. The analyses in each report remain within the author's specialized field, but provide totally new perspectives and insights.

This book was conceived in order to provide a more integrated look at Japan's experience with technological development than could be expected from the individual studies, and with the aim of suggesting how the Japanese experience might offer a useful reference for countries now undergoing technological development. This overall report covers the years up to 1980.

The reports are structured so that the years from 1867 to 1980 are divided into eight different periods. Each chapter begins with a general description of the features of the period in regard to railroad and road transport and river and coastal shipping and then examines specifics for each transportation mode. The first chapter examines the transportation system in the Edo period that was in existence prior to technological transfer. The second chapter explains the situation during the beginnings of transfer (1868–1891). Chapter three deals with the 1892–1909 period, which marked the start of Japan's railroad era and the establishment of a modern transportation system. Chapter four takes up the development of sea transport during World War I and the domestic production of ships and motor vehicles. Chapter five discusses the period 1922–1937, in which land and sea transport were organically synthesized by constructing large piers and land routes near the ports. It also discusses the development of urban railroads and motorization. Chapter six concerns transportation during World War II. Chapter seven examines the problems of the post-war recovery period 1946–1954. Chapter eight discusses developments during Japan's rapid economic growth.

The development of transportation in Japan is of course an individual case that cannot be seen apart from what was happening on the world and domestic historical stages from the 1860s to the 1980s. Although Japan's experience is one that cannot be applied directly to the developing countries as a model of technological transfer, there are certain factors that can be selected from specific conditions that give the Japanese experience great worth, at least as a reference. Judgments of value must, however, be left to the reader. Finally, all members of the study group would like to thank the United Nations University and the Institute of Developing Economies for their support.

Hirofumi Yamamoto

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Traditional Transportation Systems

Hirofumi Yamamoto

Roads

The shogun and feudal lords of the Edo period strictly controlled road transportation. Five main highways radiated out from Edo (present-day Tokyo), the seat of the central government. Every 10 kilometres or so along the five roads stood post-station settlements with horses, bearers, porters, and inns always ready for the travel and lodging needs of the samurai class. Officials appointed by the *bakufu* (the shogunate) were assigned to the post-stations to directly control transportation and lodging. Each post-station along the Tokaido – the main highway between Edo and Kyoto, residence of the emperor – had 100 transport workers, porters, and bearers, and 100 horses on duty at all times. Next in order of highway priority was the Nakasendo, where 50 persons and 50 horses were permanently detailed to each post-station. Post-stations on the other three highways, the Koshu Kaido, the Nikko Kaido, and the Oshu Kaido, had 25 bearer-porters and 25 horses each. Highways other than these five were secondary, lacking the importance and volume of traffic of the main highways. Secondary highways were under the control of local lords, who set up post-stations and stables for fresh horses and bearers, the number of which was determined by traffic levels. However, samurai still had preference in the use of facilities and at amounts much lower than the going rate. But even they could not do as they wished; they had to comply with limits on use just as everyone did, for limits determined by class were placed on all users. Rented horses and bearers transported people or cargo only as far as the next station, where it was necessary to hire another relay to reach the next stage of the journey.

To prevent hostile forces from entering the capital, inspection stations with sturdy wooden gates were built along each highway. Further defence measures were designed to prevent all wheeled vehicles from using the roads and forbade the construction of large bridges over rivers.



Fig. 1. Traffic network at the end of the Edo period

To compensate for the burden of providing transportation and lodging services to the ruling classes, post-stations were exempted from certain land taxes, provided with subsidies at a fixed rate, and permitted to do business in transportation and lodging with commoners. However, the government restricted the use of bearers, horses, and lodging by commoners so that they would not hinder travel by the samurai class. Commoners also had to pay the going cost. The samurai demand for transportation was very high and if bearers, porters, and horses on permanent station in the post-stations could not handle the traffic, auxiliaries would be drawn from neighbouring villages. The villages' corvée labourers were attached to each post-station and, each time the need arose, the villages provided horses and bearers who would be under the direction of a post-station official. The villages were

compensated for this service by exemption from certain taxes. But the exemptions were not enough to offset the costs for transport labour. Village debt increased continually throughout the Tokugawa period, so that by the *bakumatsu* (1853–1868), the decline and fall of the shogunate, many villages were financially exhausted.

The transportation system that the new Meiji government inherited from the *bakufu* was feudal, requiring mandatory corvée labour from post-stations and nearby farms to make it go. The government needed time to renovate the system because, as well suited as the framework was to feudal military and administrative use, the highways and subordinate facilities had not been improved in 200 years and were in an underdeveloped state not suited to industrial and commercial use. Another obstacle to immediate re-vamping was the civil strife occurring when the new government took power. That strife made the government fully aware of the military role of transportation. Even after clear assurances of victory, the government clung to the system and, in June 1868, expanded the transportation labour force levy to every village in the country. The official reason for the decree was fairer distribution of corvée, but the government's continuing high demand for transportation meant an equally heavier burden on all villages. Military and administrative road use stayed at the same high levels as always, restrictions on bearer and horse fares remained almost unchanged, and the low rates for official road use were about the same.

The villages on which corvée was newly imposed protested vehemently, pleading diverse reasons for exemption. The government found it more and more difficult to obtain the necessary men and horses. The real value of the fixed price for public road use declined by half because of civil-war-induced price inflation, and the emergency increases in transport labour greatly impeded farm work. The government dealt with the protests by issuing a series of decrees, some of which rebuked the villagers for laziness, others that sought to appease them. The economy was the final arbiter, however; it eventually proved impossible to procure large amounts of labour from farm villages at rates that were both fixed and far cheaper than real prices. Under pressure from farmers demanding fair wages, the government was in the unenviable position of continually loosening the overall restrictions on the amount of horses and labour and increasing the fixed price.

These concessions increased government costs and rapidly undermined the basis of support for a system that was fast becoming unworkable. The government's railroad construction that began in April 1870 was another factor reducing the need for official supervision of road transport. As a result, when the first railroad opened between Shimbashi (now Shiodome) and Yokohama (now Sakuragicho), people living along the roads were allowed to contract transport work at each post-station. Then, in 1875, the work was completely privatized – anyone could apply to the government for permission to operate a transport business and the conditions for granting licences were all the same.

River Transport

As overland transportation performed important functions in the military and administrative context, so too river and auxiliary facilities (docks, inspection stations, etc.) played a vital role in distribution as the major mode for transporting tributary rice and other cargo under the *bakuhau* system, the dual structure of feudal rule under the shogunate and some 270 baronial domains. This role in cargo transport was equivalent to the military and administrative role of the roads and subordinate facilities such as the post-stations and inspection stations. The construction of castle towns and the *sankin kotai* system (alternate residence, in which each lord was forced to spend several months every other year in the shogunal capital of Edo and leave there members of his family as hostages when he returned to his domain) show how closely the feudal lords were linked to the urban-centred commercial economy from its inception. Under this framework they had to sell their tributary rice and other goods so that they could buy necessary consumer goods and services. To satisfy these requirements, feudal lords in every region began in the early years of the Edo period to reclaim rivers and construct new river-banks for loading and unloading goods. Representative examples are Suminokura Ryoi's reclamation of the Fuji and Tenryu rivers in 1607 and Kawamura Zuiken's reclamation of the Abukuma River and the Mogami River in 1671–1672. Most Japanese rivers flow fast and short out of mountain ranges running along the country's spine, but despite the obstacles to navigation, transportation became possible through dredging and reclamation and the use of boats of many different types and sizes. Goods loaded onto a small boat at the upper reaches of a river would be re-loaded into a larger craft where the river was wider. At the mouth of the river, the load would finally be transferred to a large cargo ship. Transfer of freight along the river was controlled by river-bank agents. But despite such difficulties, there were fewer reloads and thus fewer damaged goods than in road transport; river transport was cheaper and it could carry much more cargo. This made the rivers important highways throughout the Tokugawa period for hauling tributary rice and other goods, as well as passengers and cargo from commoners.

Banks were built along all navigable rivers, and those engaged in river transport included river-bank agents, boat owners, boatmen, and stevedores. The agents handled the stevedores and cargo transportation. Some of what the cargo owner paid went for boat-owner fees, the rest for agent's handling fees.

As time went on, some river-bank agents bought their own boats and engaged directly in transportation work. The agents provided mandatory offerings to the shogunate and feudal lords for authorization to operate. In many cases, the agents were also village officials or road agents, providers of bearers, porters, and horses to travellers and cargo owners. Directing boat owners, boat handlers, and stevedores, the river-bank agents worked together to organize river transport. During the Meiji period, they joined

forces with a major transportation company, Naikoku Tsuun Kaisha, and many operators who aided in modernizing river transport were former river-bank agents.

Coastal Shipping

The sealing of the country to foreign entry and native exit and prohibitions on construction of large ships in the early Edo period confined sea transport to the coast for more than two centuries. The prohibitions deprived Japan of all opportunity to develop the arts of deep-water navigation and ocean-going shipbuilding acquired from the West in the latter half of the sixteenth century. Japanese ships were now limited to the single-square-sailed flat-bottomed Yamato *bezaisen* and the navigation techniques were restricted to those usable only in coastal waters. However, coastal-sea transport flourished as the *bakuhan* system solidified and the volume of tributary rice and other goods increased.

Farm villages in the Kanto region cultivated mainly dry crops, which lacked the potential of the Kinai's wet-rice paddies to sustain large populations and could not keep up with consumer demand from Edo. To keep watch on the feudal lords, the Tokugawa shoguns extended the land they controlled strategically throughout the country. Under the *sankin kotai* system, which the shogunate devised to keep the lords impoverished and under central control, the feudal lords were required to spend part of alternate years in Edo, to provide tribute to the shogun, to build villas in Edo, to keep their wives and children in the shogunal capital as hostages, and to ship rice and other consumables from their home provinces. This provided the initial boost, in the 1620s, for the ships of the Higaki Line to begin plying the waters between Osaka and Edo and supplying the Tokugawa capital with cotton, oil, sake, vinegar, soy sauce, and other everyday articles. By the 1670s, another service between Osaka and Edo, the Taru Line, was transporting to Edo sundry articles such as sake, paper, lacquer, and hardware goods. From 1700 to 1702, 4,036 of these ships docked in Edo.¹

Two other main lines flourished mightily after their start in the 1670s: a western sea route carrying tributary freight from the Tohoku, Hokuriku, and San'in regions to Osaka and Edo, and an eastern route carrying similar goods along the Pacific coast from Dewa, Sanriku, Iwashiro, and Iwaki to Edo. Ships on these routes carried return cargo from the Inland Sea regions of salt, ginned cotton, cotton cloth, paper, and oil. Thus, many large ports were opened along the Japanese coast and eventually formed themselves into a coastal navigation network.

However, after ports were opened to foreign shipping in the *bakumatsu* period, non-Japanese ships posed a strong threat to the prosperity of native coastal shipping. British consular reports² from 1868 to 1872 indicate that foreign ships carried a large portion of domestic goods in and out of the open ports of Yokohama, Kobe, Hakodate, Nagasaki, and Niigata.