The co-evolution of international business connections and domestic technological capabilities: lessons from the Japanese catch-up experience

An essay in memory of Sanjaya Lall

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We undertake an examination of the technological catch-up experiences of the leading Japanese industrial firms in the twentieth century, based on both qualitative and quantitative historical evidence. We argue that the international business connections of Japanese firms had a strong influence on the industrial composition of the catch-up of their technological capabilities, and that in turn that catch-up has led to a change in the nature and form of their international business connections. We speculate on some similarities and differences with the current catch-up of firms in emerging market economies.

Key words: technological catch-up, technology transfer, international business connections, business networks, Japan, China

1. Introduction

During the course of the twentieth century, and especially between the 1920s and the 1970s, the largest Japanese firms caught up economically and technologically with their United States and European counterparts (e.g. Minami, 1994). Their technological capabilities were initially basic and highly imitative, grounded on the achievement of operational efficiency and standard product design, but over time, they steadily became more complex and sophisticated, and increasingly knowledge-intensive. In the course of this transition, they increasingly relied on knowledge creation and absorption, leading to the development of internal research and development (R&D) capabilities. At the firm level, the leading Japanese companies went from being aspiring emulators of Western models of organization and technology to being world-class companies in their own right. At the industry level, there

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was industrial upgrading, in the sense of a structural shift towards industries whose products were more science-based or characterized by more complex engineering methods and design capabilities (Ozawa, 2000, 2005). Such structural change tends to become more difficult as a country or a national group of firms moves up to higher rungs on the ladder of economic development (Lall, 2001).

The technological learning of firms has been a central part of every catch-up story, although this micro aspect has often been neglected in the macro-institutional and policy environment studies that have dominated the catch-up literature (e.g. Gerschenkron, 1962; Fagerberg and Godinho, 2005). While these studies provide valuable discussions of the role of the institutional changes that have facilitated catch-up at the national level (such as in the banking or education systems), they typically have little to say about the variations across firms and industries with regard to the firm-specific factors associated with capability-building over time. Unlike the neoclassical view of catch-up as the accumulation of physical and human capital, the evolutionary perspective frames catch-up as a process of gaining access to and mastery of the technologies used by the leading countries of the era (Nelson and Pack, 1999). Firms are repositories of knowledge/technology (Kogut and Zander, 1993), and the competitive advantage of firms in a country is the foundation of national competitiveness.

We know that firms co-evolve with their institutional environment (Murmann, 2003; North, 1990), be it in the domestic or international context. In the catch-up experience of developing countries, the importance of international business connections for a country's development has been observed repeatedly (Dunning and Narula, 1996). In Japan, international business connections played a critical role in the catch-up of its firms, although the forms of these connections have changed over time (Ozawa, 1997). The propensity of Japanese society and firms for adopting and adapting foreign practices has long been noted, and their approaches to catch-up emphasized imitation by the leading firms of the more advanced western countries ever since the late nineteenth century.[1]

Therefore, largely in accordance with the approach of Sanjaya Lall (Lall, 1992, 2000), the central research question addressed in this paper is somewhat different from the usual aggregate-level perspectives offered by most economic development theories. We focus on the changing relationship between international business connections

[1] See e.g. Westney (1989).

and the technology development paths of the largest Japanese firms, especially in terms of their changing industrial structure, allowing for the specific context provided by the institutional environment in Japan.

In this paper, we argue that the evolution of the innovative capabilities of the largest Japanese firms was strongly influenced by their earlier international business connections. The industries in which international business connections were most significant and most effective were also those in which the subsequent catch-up of indigenous capabilities were strongest – an effect that seems to have persisted in a path-dependent fashion long after the relevant international business connections were discontinued or loosened. Moreover, we contend that there was also an effect in the reverse direction: as Japanese firms caught up technologically, the nature and form of their international business connections shifted over time. This was partly because there was a change in the forms of international business connections sought or required by large Japanese firms at different stages of development, and partly because of changes in the relevant policy or support regime provided by the Government.

More specifically, there was a shift from a strong form of dependency in the interwar period on close affiliations or interactions with foreign-owned subsidiaries located in Japan to the arm's-length cross-border licensing of foreign technology in the post-war period, while all the time being accompanied by vigorous autonomous in-house R&D efforts. However, while these looser international business connections of cross-border licensing were sufficient in the early post-war period to build world-class electrical equipment and motor vehicle industries, they also led Japanese industry to become locked into a particular path of locally driven development. Therefore, in more recent times, as world leaders themselves in an environment of greater international knowledge connectedness, Japanese firms have begun to shift back towards closer forms of international business connections again. They have come to recognize the desirability of building international innovation systems involving cross-border networks (which may be, to some extent, at the expense of the traditional domestic business groups), and hence require a rise in both inward and outward foreign direct investment (FDI).

We claim further that studying the experience of firms in Japan may offer some lessons for firms in other countries as well, once we take account of the specificities of different historical periods. Bearing in mind the different context for catch-up today compared to that of 50 years ago, we consider some aspects that firms in emerging market economies today may be able to learn from Japanese firms, as well as those they may now need to do differently.

In the following sections, we examine Japanese firms' technological catch-up and post-catch-up experience, beginning from the interwar and post-war periods. In doing so, our goal differs from the predominant approach in business research, in that we are trying to draw analytical inferences from historical experience to help establish a framework for examining the co-evolution of international business connections and indigenous corporate technological capabilities, rather than imposing or testing some given prior theory. The main contribution of our paper is in our interpretation of the evidence and in making analytical connections between various trends (notably between the paths of international business connection and domestic firms' capability-building) that are consistent with the historical evidence. Based on archival evidence, and on historical data on technology licensing and corporate patenting, we note how the technological catch-up experience of Japanese firms relates to their changing international business connections over time. Then, in some concluding thoughts, we consider the extent to which one might legitimately extrapolate from these historical lessons, and in doing so, we speculate on some similarities and differences with the contemporary experience of catching up in other emerging market economies, most notably those in East Asia.

The paper is structured chronologically, to follow the relevant sequence of catch-up processes that we are interpreting. In the next section, we review the role and composition of the international business connections of Japanese firms in the interwar period. These international business connections played an extremely important role in the early technological catch-up experience of Japanese firms, which benefited a great deal from close relationships with foreign firms, which resulted in knowledge spillovers and technology transfer. In the third section, we consider the catch-up process of the post-war period. Japanese firms initially borrowed and imitated foreign technologies acquired through international licensing. At the same time, they engaged in their own R&D to modify and recombine the technologies learned, and thereby gradually built their own more advanced capabilities. We show that the industrial composition of catch-up reflected the pattern of international business connections from the interwar years, as well as the then contemporary composition of technology licensing. In the fourth section, we examine the shift back towards closer international business connections through (outward as well as inward) FDI in more recent years, as Japanese firms themselves have become world leaders and need to keep at the cutting edge of technology development worldwide. In the final section, we discuss some observed similarities and differences in the catch-up of firms in emerging market economies today, and reflect on how these relate to the contemporary global economic environment.

2. Interwar knowledge transfer and spillovers from FDI

In this section, we focus on the first stage during the modern Japanese catch-up process – the interwar period – and illustrate the critical importance of inward FDI in the earlier phase of the technological catch-up of Japanese firms. The main inferences we draw in this section are as follows. First, when local capabilities are still at an early stage of development, relatively close forms of international business connections (which may include local participation through FDI) seem more desirable. Second, in industries in which such close connections can be established with innovative foreign firms, local capability development can gain a substantial and lasting momentum.

After the Meiji Restoration of 1867, Japan made a determined effort to catch up with the western countries. The Government put special emphasis on education, entrepreneurship, and learning the technologies and organizational systems of western countries. Hired foreigners (*Oyatoi Gaikokujin*) played an important role in transmitting scientific knowledge, mainly from the United States and Europe. Through this continuous process, Japanese firms had accumulated considerable technological capabilities by the beginning of the twentieth century, which formed the foundation for their ability to absorb the new technologies from western countries during the country's industrial revolution.

It is well known that during the interwar period, many leading transnational corporations (TNCs) expanded their business in Japan. The existence of foreign affiliates or joint ventures served as a fertile learning ground for the acquisition of technical, managerial and organizational knowledge in the host country (Chandler and Hikino, 1997; Lockwood, 1954). Being the key pioneers of modern technologies, these TNCs were used as a model for the technological learning of Japanese firms. It was a critical period, in which Japanese firms built the foundation and capability needed for modern industries, and this capability enabled Japanese firms to catch up quickly later, despite having to overcome the devastation of the Second World War.

Many of the major Japanese companies today and their respective industries benefited significantly from their interwar relationships with western companies. Japanese companies used the more mature industrial technologies of their western partners as a model for their technological learning and catch-up. Many alliances and joint ventures were formed in the interwar period, mostly at the request of large Japanese enterprise groups known as *zaibatsu* (the pre-Second World War predecessor of the current *keiretsu*), as they were well aware that they were lagging behind the West in their technologies and felt the urgency to catch up with the advanced technologies and rapid rate of innovation in the Western countries (Fujita, 1989). The size and power of the zaibatsu, the span over different industries, and the breadth of technological capabilities within zaibatsu groups allowed zaibatsu firms to better absorb a diversified set of technologies from foreign partners, and brought about the process of catching up over a broad front of technologies and products.

Thus, FDI in Japan during this period proved highly significant in terms of its qualitative transformational effect, even though the total value of inward FDI in Japan during the interwar period was small (Dunning, 1983; Udagawa, 1989). Table 1 shows the state of the foreign-affiliated manufacturing companies operating in Japan surveyed by the Ministry of Commerce and Industry in 1931. This table is illustrative of the influence of inward FDI during the interwar period upon the subsequent technology development paths of Japanese firms. According to this survey, there were 88 foreign or jointly-owned companies operating in Japan. We can see that the more competitive industries found in Japan today generally had more linkages with foreign-owned firms during the interwar period, especially in the case of firms in the machinery and electrical apparatus industries. Corporate technology development is a path-dependent and firm-specific process (Nelson and Winter, 1982; Rosenberg, 1982; Cantwell and Fai, 1999), and the initial conditions under which technology is developed are often critical for the subsequent accumulation of capabilities. The evidence portrayed in this table suggests that the foundation of what became the strongest indigenous Japanese industries can be traced back to the linkages built up with large western companies in the interwar period, and their success at that time in utilizing these linkages effectively to learn and master the then modern technologies in the process of catch-up.

In the remainder of this section, we turn to more detailed evidence on two industries to showcase the significant role of international business connections in the technology development of Japanese firms. The focus here is on the motor vehicles and electrical equipment industries, in both of which Japanese firms have grown to positions of significant competitiveness in the post-war world economy.

Table 1. Foreign-affiliated companies in Japan (manufacturing), by product and type of ownership (as of January 1931)

I. Foreign corporations (sales offices): 29 companies			
By country of origin		By product	
United States	15	Machinery	18
United Kingdom	5	Electrical apparatus	3
Germany	5	Food	3
Switzerland	2	Movies	2
Czechoslovakia	1	Art	1
Luxembourg	1	Petroleum	1
		Silk yarn	1
II. Corporations under Japanese law			
A. Fully owned and operated by foreigners: 13 companies			
By country of origin		By product	
United States	6	Electric apparatus, machinery, automobiles, and food	2 in each
United Kingdom	5	Records, rubber products, petroleum, machinery, and photographic paper	1 in each
Germany	2		
B. Mostly owned and operated by foreigners: 10 companies			
By country of origin		By product	
United States	6	Records	5
United Kingdom	2	Machinery	3
Germany	2	Automobiles and rubber products	1 in each
C. Jointly owned by foreigners and Japanese, operated by Japanese: 36 Companies			
By country of origin		By product	
United States	9	Electric apparatus	8
United Kingdom	9	Cotton yarn	6
Germany	8	Rayon	3
China	2	Steel	3
Switzerland	1	Wool products	2
France	1	Machinery, gas, glass, ice, celluloid, matches	1 in each
Unidentified	6	Unidentified	6

Source: Udagawa (1989).

At the turn of the twentieth century, amid such rapid technical advances in electrical machinery, Japanese companies found that the gap in technology was too wide for them to bridge by themselves. Because this was considered such an important and fast-developing industry, most of the major electric machinery manufacturers in Japan (most of them zaibatsu companies) established affiliation with leading western companies in the interwar period to learn cutting-edge technologies. In the heavy electrical equipment industry, for example, the four dominant companies, which were all *zaibatsu* affiliates, all became associated (with the exception of Hitachi) with foreign heavy electrical machinery manufacturers. Shibaura Engineering, an affiliate of the Mitsui zaibatsu, formed a link with General Electric. Mitsubishi Electric, an affiliate of the Mitsubishi zaibatsu, formed an affiliation with Westinghouse Electric in 1923 and offered Westinghouse 10 per cent of its stocks. The Fuji Electric Co. was established in 1923 as a joint venture of Furukawa Electric Industry, a company of the Furukawa zaibatsu, and Siemens (Udagawa, 1989).

A particularly prominent example in the heavy electrical equipment industry was the tie-up between two of the major Japanese companies – Tokyo Electric and Shibaura Engineering – and General Electric, one of the world's most technologically advanced and diversified firms at that time (and today). General Electric formed an equity joint venture with Tokyo Electric in 1905 and Shibaura Engineering (Mitsui affiliated) in 1909, at the request of the Japanese zaibatsu.[2] General Electric received equity – Tokyo Electric allotted 51 per cent of the stock to General Electric at the start of the joint venture and Shibaura Engineering transferred 24.75 per cent of the stock to General Electric – for the technical assistance it provided and also royalties for the sale of equipment. These associations with General Electric allowed Tokyo Electric and Shibaura Engineering to rapidly raise their technological levels and to diversify into related technological fields. The joint ventures allowed Japanese electrical equipment companies to receive technological know-how and guidance, and also to buy plant and equipment. New production methods such as the integrated production system of large United States companies (vertical integration) were adopted, and the frequent dispatching of personnel to the home base of the tie-up partner was critical to the success of technological learning (Chokki, 1989; Fujita, 1989).

As the result of the technological assistance from General Electric, Tokyo Electric's light bulb production technology was rapidly modernized. All the necessary plant and equipment was ordered from General Electric. The output increased two-fold and the cost reduction was large. The capacity to produce carbon filaments and metal caps was boosted with the installation of production machinery with an output capacity of 10,000 carbon filaments per day and a set of metal-cap-fabricating machinery. Furthermore, light bulbs produced by Tokyo Electric were marketed after 1906 under the Edison trademark, and the brand impact strengthened their acceptability in the national market (Chokki, 1989). At the time of the joint venture with General Electric,

[2] Tokyo Electric and Shibaura Engineering later merged in 1939 to form Toshiba.

Shibaura Engineering was the sole domestic maker of heavy electrical machinery, but its production was limited to generators of less than 100 kW, far below the level of western makers (Chokki 1989; Fujita, 1989). When the tie-up between Shibaura Engineering and General Electric formally started in 1909, General Electric provided technical designs and supplied necessary raw materials and parts, but sent only one or two directors. General Electric received a royalty of 1 per cent of sales (Fujita, 1989). Many key personnel dealing with design and production in Shibaura Engineering were sent to General Electric in April 1910 to study their technology and visit their factories. Shibaura Engineering continued to send trainees to General Electric, and occasionally dispatched employees to observe work and learn technologies at General Electric. As a result of the connection with General Electric, Shibaura acquired the ability to manufacture large generators, transformers and induction motors. Subsequently, its productivity, profits and dividends rose. Furthermore, this facilitated its entry into the manufacture of fans and household appliances as well as radio communications equipment, thereby establishing the foundation for developing into a general electrical equipment manufacturer (Chokki, 1989).

As an illustration of General Electric's technical support to Shibaura Engineering, General Electric helped Shibaura Engineering set up from scratch the new Tsurumi plant for electric locomotives, for which General Electric provided total support in all aspects from building the plant to technology provision and factory management (Chokki, 1989). Many materials from that time in the General Electric archive in Schenectady (which we, the authors of this paper, have examined for this purpose) attest to the significant help from General Electric to Japanese firms and Japan's massive modernization and electrification process. Among them, we can find a warm personal letter from the president of Shibaura Engineering to General Electric to thank it for its help in the building of the Tsurumi plant after the 1923 Kanto Earthquake, pictures of General Electric engineers working on the plant site as wll as in the factories helping set up activities in the new plant. Articles from the General Electric magazine (GE Digest) in the interwar period described the relationships between General Electric and Shibaura Engineering and Tokyo Electric, and how General Electric helped bring a broad array of products that were new to Japan, including larger generators, transformers and induction motors, household appliances and radio communication, and motors for electric trains and the Tokyo subway system.

The motor vehicle industry was another new industry that emerged in Japan during the interwar period under the aegis of American influence (Wilkins, 1989). The indigenous motor vehicle industry in Japan started from an entirely foreign-owned sector in the 1930s, when companies such as Toyota and Nissan, both small start-up companies at that time, decided to enter. Nissan bought the vehicle design and technology from Graham-Paige (the 14th largest auto maker in the United States), and acquired technological assistance from Graham-Paige and its suppliers. Graham sold machinery, arranged for Nissan employees to study at its plant, and also built a prototype for Nissan. Nissan signed contracts with several of Graham's suppliers in the United States and had them send casting machinery to Japan, set it up, and teach Nissan engineers how to operate it. Nissan also initially hired American engineers to direct all Nissan's operations and set up the production. These head engineers not only taught the Japanese how to operate the equipment properly, but also applied modern techniques for process control and standardization to improve Nissan's machine processing (Wilkins, 1989).

Unlike Nissan, Toyota developed its own vehicle from the very beginning, by studying and reverse engineering the American vehicle models, since Toyoda Automatic Loom (predecessor of Toyota) had already accumulated engineering capabilities needed in automobile production. Toyota engineers disassembled and studied American cars, and the first car they built was a hybrid, with a Chrysler body, a Chevrolet engine, and Chevrolet and Ford parts. Toyota also sent its employees to visit foreign factories. For example, in January 1934, Toyoda Automatic Loom's specialist on engine casting visited Ford, General Motors, Chrysler, Packard, Graham-Paige and others to study factory design, parts manufacturing, and materials, and came back with machine tools (Cusumano, 1985).

In spite of the different approaches that Nissan and Toyota took, they both initially relied heavily on United States manufacturers, sending employees to the United States to study factory design and operation, vehicle assembly and parts manufacturing, and to obtain machine tools and materials. Furthermore, the take-off and development of these two companies owed much to the presence and efforts of Ford and GM in Japan for setting up the infrastructure and training employees and suppliers (Ozawa, 1997).

In the 1920s, Ford and General Motors established assembly plants in Japan in response to the large demand for trucks by the Japanese army. Attracted by the demand in Japan, Ford established Nippon Ford (Ford Japan) in 1925, and later constructed a larger factory in Yokohama to assemble cars and trucks. In 1926, General Motors, impressed by Ford's profits in Japan, followed suit and opened its large plant in Osaka in 1927 and started assembling vehicles in Japan. Besides cars, Ford and General Motors also produced many trucks for military use, as well as three-wheeled vehicles. Although no joint ventures were formed in this industry, the demonstration effect (Dunning, 1958) from the local presence of United States car companies in Japan was enormous. There are principally four ways in which United States companies contributed to the start-up and development of the Japanese motor vehicle industry.

First, as discussed above, the emerging Japanese car manufacturers used American cars as their models. In spite of the different approaches that Nissan and Toyota took, they both benefited a great deal from sending personnel to United States car companies. At that time, United States companies such as Ford and GM were not afraid to transfer their technology to Japanese manufacturers; they had no fears about nurturing future competitors because of their own strength and confidence (Wilkins, 1989). At one point, around 1935, Ford was even prepared to transfer technology for the highest value-added components – the transmission mechanism and the engine – to Toyota in order to form a joint venture to allow it go into manufacturing, although it failed to do so due to government and army opposition (Mathews, 1996).

Second, Ford and GM trained and developed automobile parts suppliers, which were critical to establishing a local motor vehicle industry. As Ford and General Motors began assembly operations, they began to buy parts locally in line with their worldwide practice. One of Ford's early suppliers was Nissan, and Nissan acknowledged that its major motive for becoming a supplier to Ford was to learn (Cusumano, 1985). Local suppliers trained by Ford and General Motors became a critical factor for Japanese local companies in their attempt to start an indigenous motor vehicle industry. In the mid-1930s, when Toyota and Nissan decided to manufacture motor vehicles, there were already a group of capable local suppliers. Subsequently, these suppliers were urged to defect from Ford and GM, and sell to Japanese companies (Wilkins, 1989).

Third, Ford and GM set up a dealer network in Japan and adapted it to the Japanese market. Their networks were later utilized, imitated and taken over by Japanese car companies. The dealership system is an American innovation that contributed greatly to the development of the motor vehicle industry. Before Ford and GM began operations in Japan, there were no sales agents dealing in such durable consumer goods as automobiles. Ford and GM therefore both developed their own dealer organizations in Japan. By about 1930, Ford and GM each had between 70 and 80 franchised dealers, and had set up qualifications and regulations for their dealers. In that sense, the automobile industry in Japan had from its outset an extremely modern and rational sales organization (Udagawa, 1981).

Fourth, American companies trained Japanese personnel for assembly operation, purchasing and sales, who later contributed to the local industry's development. In the case of Ford, it started with mainly foreign personnel. Over time, Ford hired more Japanese employees. By 1932, Ford had 381 Japanese employees and GM had 719 (Mason, 1987). Many of them later worked for Japanese motor vehicle companies, taking the skills and knowledge they had learned with them. The personnel linkage effects in this industry were formidable. For example, Kamiya Shotaro, the highest-ranking Japanese staff member at GM, joined Toyota in 1935 as sales manager. Together with the knowledge of a good sales network, he brought with him Hinode Motors, a leading GM dealer and two of his principal subordinates in the sales and publicity department, and he also went about convincing Ford and GM dealers to join the Toyota organization (Cusumano, 1985). Technological progress played an important role in Japan's economic growth. As estimated by Minami (1992), 65 per cent of the growth of per capita production in mining and manufacturing in the period 1908–1938 is accounted for by the residual factors, i.e. mainly technological progress. The main sources of this technological progress were both developing indigenous technology and learning from foreign technology (Odagiri and Goto, 1996).

3. Post-war technology licensing and structural upgrading

However, like the situation in the other industries, the dominant position of American companies in the Japanese market in the late 1920s generated opposition from the army and the Government. Later, they began to make conditions increasingly difficult for the United States-owned companies. Realizing that Japanese firms had, by then, built up their own basic capabilities, the Government started to limit foreign businesses in Japan. In the case of the electrical equipment industry and motor vehicle industries, as local capability accumulation progressed, the desired form of international business connections became one of looser and less direct relationships, but those industries and firms that had once enjoyed close international business connections continued to benefit from the strong initial momentum that they had gained, collaborating with foreign firms for a considerable time to come.

In the case of General Electric, towards the later part of the interwar period, the growth in domestic Japanese firms, together with nationalism and militarism, resulted in General Electric's involvement in Japan being sharply reduced (Chokki, 1989). In the early 1930s, the Board of Directors of Tokyo Electric expressed a desire to reduce the "foreign" influence. The company decreased its capital stock, gradually reacquiring General Electric's holdings, which were cut from 57.0 per cent in 1931 to 32.5 per cent in 1936. In July 1939, Tokyo Electric and Shibaura Engineering merged to form Tokyo Shibaura (or Toshiba). At first, General Electric's share was 32.8 per cent, with the second-largest shareholder being the Mitsui zaibatsu at 14.8 per cent. But not long afterwards, General Electric's share in the company was halved (Wilkins, 1982).

In the case of the motor vehicle industry, by the 1930s, the Government had passed legislation which allowed only Japanese companies to manufacture locally. The most important pre-war legislation, passed in 1936, restricted imports and assembly of vehicles by foreign companies in Japan. Ford and GM tried to bypass Government regulation by forming joint ventures with Toyota or Nissan, but failed to do so due to Government and army opposition (Wilkins and Hill, 1964). The result was that whereas Japan Ford, Japan General Motors and other foreign companies had accounted for more than 95 per cent of new vehicle registrations between 1926 and 1935, the production share of Nissan, Toyota, and Isuzu rose to nearly 57 per cent by 1938 and to 100 per cent in 1938, when Japan Ford and Japan General Motors ceased operating and Japanese motor vehicle companies had practically taken over the market, supplier network, and employees of Ford and GM in Japan (Cusumano, 1985).

We can see that the Government's policies towards FDI, which were initially encouraging but became restrictive later, played a central role in the development of modern Japanese industries. The Government and indigenous firms would take the lead in inviting foreign companies to invest in Japan or to set up joint ventures, but would then limit or eliminate their operations once local firms had learned the modern technologies from foreign firms and achieved a certain level of capabilities. What this suggests is that policy and firm capabilities co-evolved through the different phases of catch-up, rather than one leading the other.

Another example in this regard is the telephone industry. Having become dissatisfied with the quality of telephone sets produced by Japanese firms, the Ministry of Communications sent officials to the United States and Europe and adopted some of the Western Electric system (Mason, 1989). At the strong encouragement of the Government, in 1899, Western Electric combined with the Japanese company Iwadare Kunihiko to form the joint venture Nippon Electric Company Ltd. (NEC). At its inception, the company's capital was 200,000 yen, and the initial Western Electric holding was 54 per cent of the shares (Morris-Suzuki, 1994).

However, in common with the fate of many other industries with significant involvement of foreign companies, government policy subsequently changed. In the late 1920s, the authorities began to shift more of their procurement to Japanese-run manufacturers such as Oki Electric and Toa Electric – which by then had become able producers of many types of communications equipment. The Ministry of Communications took this new policy direction one step further and decided in 1930 that only telephone manufacturers whose capital was primarily held by Japanese interests would qualify for privileged consideration in domestic procurement (Mason, 1989).

Owing to the rising power of the military leading up to the Second World War, TNCs were practically forced out of Japan in the 1930s. After the Second World War, FDI in Japan was highly restricted for many years, and Japanese firms relied on licensing in place of FDI for technology transfer, which was possible because Japanese firms had already built a foundation for modern industries from their earlier direct involvement with foreign companies through joint ventures or the presence of foreign TNCs in Japan. The leading Japanese industrial firms had achieved a certain level of absorptive capacity, so that they could rely on arm's-length licensing to fulfil their technological requirements in the post-war period.

The Government regulated technology importation, guided the direction of technology imports, and approved technology licensing agreements on a case-by-case basis. The Foreign Investment Law, enacted in 1950, was to promote an inflow of foreign capital and technology. In 1950, there were only 27 technology purchase contracts with an effective life of more than a year, but subsequently this number grew markedly to reach 1,061 in 1969 (Ozawa, 1974). Technology imports contributed a great deal to the post-war development of technological capabilities in Japanese firms.

R&D by indigenous firms in Japan was stimulated and accompanied by licensed technologies. Thus, licensing and R&D together provided the foundations for the performance of Japanese firms. The structure of what became the most successful post-war Japanese industries and their leading companies was built on the technological foundations laid in the interwar period with the assistance of foreign firms. The pattern of technological specialization was then augmented through inward technology licensing, which was reinforced and further enhanced by firms' own increasing R&D efforts. In particular, we can clearly see a pattern of path-dependency with steady industrial upgrading in the technological endeavours of Japanese firms from the 1920s through to the 1980s.

After the Second World War, the zaibatsu groups were broken up by the Occupation Authorities. However, owing to the long-standing institutional tradition, a new form of inter-firm networking, the keiretsu, soon emerged in place of the original zaibatsu. The keiretsu differed from the pre-war zaibatsu in that companies were now more loosely connected. No holding company was allowed, and they did not have the kind of monopoly power that the pre-war zaibatsu had once enjoyed (Bieda, 1970).

Table 2 shows the number of technology introduction contracts over the period 1950–1997. From this table emerge the dual themes of path-dependency (from the international business connections of the interwar period) and industrial upgrading of technology development (drawing upon international business connections through licensing in the post-war years). This table shows that three industries – chemicals, machinery (which includes general machinery, transportation equipment and precision machinery), and electrical machinery – consistently accounted for around 60–80 per cent of the technology introduction contracts during the post-war years. The industry classification here is a broad one, partly due to data constraints, but it is convenient for our purposes since it also reflects the primary technological categories. The predominance of these industries in technology licensing owed much to the post-war industrial policy of the Government, especially in the early years, which prioritized the chemical and heavy (machinery and transport) industries. But more importantly, it also shows the path-dependency and the self-reinforcing tendency of technology development. As each of these industries had built up a significant prior technical base during the interwar years, they were more readily able to absorb foreign technology. Thereafter, we see a fast and steady growth of technology imports in these industries, which happened to the greatest extent in the electrical machinery industry, enabling it to surpass the other industries and become the leader in foreign technology introduction from 1982.

Table 2. The average number of foreign technology introduction in major Japanese industries

(Number of contracts)

Fiscal year	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Manufacturing (A)	76	188	252	235	213	184	310	254	242	378	588	601	757	1,137
Chemicals	32	61	71	59	81	69	134	101	75	111	173	143	155	231
Machinery	27	51	80	40	29	46	50	40	45	104	138	172	260	429
Electrical machine	6	20	32	61	33	20	20	34	19	38	113	75	100	167
Subtotal (B)	65	132	183	160	143	135	204	175	139	253	424	390	515	827
Ratio (B/A)	86	70	73	68	67	73	66	69	57	67	72	65	68	73

Fiscal year	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Manufacturing (A)	1,041	958	1,153	1,295	1,744	1,629	1,768	2,007	2,403	2,450	2,093	1,836	1,893	1,914	2,139	2,116	2,142
Chemicals	233	195	247	292	362	264	361	390	358	354	335	234	212	232	255	265	298
Machinery	343	376	439	399	582	638	547	655	746	768	618	561	675	570	723	666	709
Electrical machine	106	126	102	146	256	225	229	257	349	367	249	304	297	404	377	416	414
Subtotal (B)	682	697	788	837	1,200	1,127	1,137	1,302	1,453	1,489	1,202	1,099	1,184	1,206	1,355	1,347	1,421
Ratio (B/A)	66	73	68	65	69	69	64	65	61	61	57	60	63	63	63	64	66

Fiscal year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Manufacturing (A)	2,076	2,229	2,212	2,378	2,436	2,361	2,709	2,834	2,898	3,211	3,175	3,224	3,029	3,161	3,901	3,145	2,685
Chemicals	228	201	208	190	258	215	221	246	240	218	214	226	175	180	176	170	126
Machinery	600	595	535	526	530	479	452	506	451	441	428	388	344	354	351	330	312
Electrical machine	448	633	696	817	900	934	1,274	1,341	1,604	1,972	1,988	2,132	2,023	2,092	2,105	1,996	1,735
Subtotal (B)	1,276	1,429	1,439	1,533	1,688	1,628	1,947	2,093	2,295	2,631	2,630	2,746	2,542	2,626	2,632	2,496	2,173
Ratio (B/A)	62	64	65	65	69	69	72	74	79	82	83	85	84	83	68	79	81

Source: Data kindly made available by Kyohei Hirano at Kobe University, compiled from Kagakugijyutsucho [Agency of Science and Technology] (each year), *Gaikoku Gijyutsu Donyu Nenji Hokoku [Annual Report on Foreign Technology Introduction]*, Kagakugijyutsucho Kagakugijyutsuseisaku Kenkyuijyo [Science and Technology Policy Research Institute] (each year), *Gaikoku Gijyutsu Donyu no Gaiyo [Summary on Foreign Technology Introduction]*.

With the introduction of foreign technologies, the R&D expenditures of Japanese firms also started to increase in the late 1950s. Japanese firms did not simply imitate foreign technologies. The technology imports of Japanese firms were complemented by their own vigorous efforts in R&D. Japanese firms invested heavily in

R&D, which proved crucial in developing the knowledge to support the steady building of the organizational capabilities needed to absorb foreign technologies; to learn how they could best apply them in the specific Japanese context; to modify and recombine technologies; and to innovate around them and improve upon them. Table 3 shows the R&D expenditures of the three major sectors of manufacturing (corresponding to the sectors in table 2) from 1959 to 1998. In line with the findings of table 2, table 3 also exhibits the themes of path-dependency and industrial upgrading. Again, the three industries – chemicals, machinery, and electrical machinery – consistently accounted for around 70–80 per cent of total corporate R&D expenditures in manufacturing, with the

Table 3. R&D expenditures in major Japanese industries

(In millions of yen)

Fiscal Year	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Manufacturing (A)	858	1,121	1,430	1,614	1,881	2,234	2,320	2,688	3,505	4,646	5,780	7,609
Chemicals	234	270	368	420	524	657	627	691	913	1,108	1,373	1,751
Machinery	156	249	280	297	363	472	523	616	817	1,116	1,371	1,863
Electrical machinery	212	281	390	434	504	507	515	652	858	1,258	1,693	2,278
Subtotal (B)	602	800	1,038	1,151	1,391	1,636	1,665	1,959	2,588	3,482	4,437	5,892
Ratio (B/A)	70.2	71.4	72.6	71.3	74.0	73.2	71.8	72.9	73.8	74.9	76.8	77.4

1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
8,107	9,532	11,935	14,594	15,365	17,274	19,231	20,987	24,471	28,956	33,742	37,555	42,572	47,765
1,937	1,992	2,382	3,042	3,221	3,519	3,860	4,042	4,898	5,583	6,174	6,875	7,745	8,528
2,088	2,594	3,329	4,231	4,409	4,684	5,862	6,339	7,085	8,287	9,963	10,871	11,850	13,131
2,292	2,767	3,415	3,974	4,005	4,917	5,013	5,805	6,942	8,172	10,062	11,764	14,162	16,345
6,317	7,353	9,126	11,247	11,635	13,120	14,735	16,186	18,925	22,042	26,199	29,510	33,757	38,004
77.9	77.1	76.5	77.1	75.7	76.0	76.6	77.1	77.3	76.1	77.6	78.6	79.3	79.6

1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
55,436	57,396	61,012	67,546	77,062	86,603	91,954	89,711	84,546	83,655	87,744	92,632	98,164	98,071
9,364	9,836	10,959	11,902	13,139	14,168	15,477	16,047	15,614	15,488	15,549	15,933	16,093	16,309
15,201	15,681	15,926	17,762	20,697	24,822	24,971	24,778	22,797	22,502	24,215	26,112	28,703	29,174
19,382	19,800	21,635	24,516	28,081	31,463	33,828	32,205	30,198	30,648	32,736	34,936	37,194	37,128
43,947	45,317	48,520	54,180	61,917	70,453	74,276	73,030	68,609	68,638	72,500	76,981	81,990	82,611
79.3	79.0	79.5	80.2	80.3	81.4	80.8	81.4	81.1	82.0	82.6	83.1	83.5	84.2

Source: Data kindly made available by Kyohei Hirano at Kobe University, compiled from Kagakugijyutsucho [Agency of Science and Technology] (each year), *Gaikoku Gijyutsu Donyu Nenji Hokoku [Annual Report on Foreign Technology Introduction]*, Kagakugijyutsucho Kagakugijyutsuseisaku Kenkyuijyo [Science and Technology Policy Research Institute] (each year), *Gaikoku Gijyutsu Donyu no Gaiyo [Summary on Foreign Technology Introduction].*

electrical machinery industry showing the fastest rate of upgrading, allowing it to surpass the chemical and machinery industries in R&D from the 1980s onward.

In the 1960s, Japanese firms began to produce their own original technology derived from internal learning processes (Ozawa, 1974). With technology imports and firm R&D, the corporate patenting of Japanese firms began to take off from the late 1960s and early 1970s. Our examination of United States patents granted to Japanese firms shows that corporate patenting was not significant until the late 1960s. For example, we looked into the number of patents of the Toyota Group (including the Toyota Motor Company and its key affiliated suppliers such as Aisin Seiki, Nippon Denso) from the 1920s to the 1960s, as shown in table 4. We see that Toyota had no or very few patents before the 1960s; this number began to grow in the mid-1960s, but starting from 1969, the number of patents almost doubled each year, from 14 in 1968 to 204 in 1972, over a four-year period.

Thus, table 5 shows the patenting activities of Japanese firms since 1969. It indicates the annual average of Japanese patents granted by the United States Patent and Trademark Office (USPTO) based on four- or five-year intervals from 1969 to 1995. Due to the different sources of the data, the industry classifications in tables 5 and 6 are more detailed than in tables 2 and 3. The machinery industry in tables 2 and 3 is aggregated to include general machinery, transportation equipment and precision machinery. In table 5 we see that the six major Japanese industries listed here accounted for a substantial proportion of innovative activity, around

Table 4. Number of United States patents by the Toyota Group from the late 1950s to the early 1970s

Year	Number of United States patents by the Toyota Group	Year	Number of United States patents by the Toyota Group
1920–1956	0	1965	11
1957	0	1966	8
1958	0	1967	15
1959	0	1968	14
1960	0	1969	35
1961	1	1970	58
1962	3	1971	125
1963	3	1972	204
1964	3	…	…

Source: Information compiled by the authors from the United States Index of Patents, and the United States Patent Gazette, 1920–1972, both published by the USPTO (United States Patent and Trademark Office.

90 per cent of the total patents in manufacturing by Japanese firms, with four industries – namely electrical machinery, transport, chemicals and instruments – being particularly intensive in their patenting efforts. We can also see that the electrical machinery industry stands out in that it had the highest number of patents consistently throughout the period 1969–1995. The strong foundation in electrical machinery manufacturing that Japanese firms built in the interwar period helped them catch on to the fast technological growth in this area and contributed a great deal to the technological prowess of Japan (Cantwell, 1992; Mowery and Teece, 1992). In addition, the transport and instruments industries also showed high patent number growth, and they had caught up with chemicals and joined the rank of top Japanese performers in patenting by the 1990s.

The pattern of patenting shown here in different industries helps to further illustrate the dual themes of path-dependency and upgrading in technology development. On the one hand, we see the theme of continuity, in that the industries that have the most patents tend to be those that had earlier built up a foundation of capabilities in the interwar period and had also benefited from technology licensing in the early post-war period. On the other hand, we also see the theme of technology evolution and upgrading, as Japanese firms have been continuously innovating to broaden the industrial base they laid earlier. This is particularly reflected in the rapidly rising number of corporate patents in each of the industries, but most prominently in the electrical machinery, transport and instrument industries, probably due to the importance of technological progress in these industries in the post-war

Table 5. Number of patents in major Japanese industries (average number of United States patents granted per year)

	1969–72	1973–77	1978–82	1983–86	1987–90	1991–95
Manufacturing (A)	2,000	3,656	4,650	7,792	11,948	14,242
Chemicals	435	734	757	1,023	1,569	1,704
Metals	115	222	235	398	550	754
Non-electrical machinery	32	100	162	230	276	291
Electrical machinery	814	1,253	1,648	3,190	5,322	7,251
Transport	231	569	830	1,511	2,104	1,706
Instruments	153	361	588	932	1,462	1,824
Subtotal (B)	1,780	3,239	4,219	7,284	11,281	13,530
Ratio (B/A)	0.89	0.89	0.91	0.93	0.94	0.95

Source: United States patent database compiled by Professor John Cantwell, with the cooperation of the United States Patent and Trademark Office.

period, and because these engineering-based areas best represented the comparative advantage in innovation of Japanese firms in developing smaller, cheaper and more efficient products.

Table 6 reports the export performance of the major Japanese industries from 1950 to 2000. From this table, we can see that total Japanese exports have been growing rapidly ever since the 1950s. This growth was especially marked during the high-growth period in the 1960s and 1970s, with exports growing five- or six-fold during the periods 1961–1971 and 1971–1980. At the same time, we can also see that the six major industries listed here played an increasingly important role in the export performance of the Japanese economy, with their combined share in total exports rising from 36 per cent in 1951 to 76 per cent in 1971, and to over 85 per cent after 1980. This is consistent with the pattern of technology acquisition of Japanese firms displayed in table 5, and demonstrates the competitive performance that resulted from their increasing innovative capabilities.

Thus, Japan's post-war development can be represented as a structural upgrading process which passed through several consecutive stages of transformation, proceeding from simpler to more sophisticated technologies (Ozawa, 2000). The data presented in the tables above show the industrial upgrading of the Japanese economy, the process of technological accumulation, and the growing importance of the transportation and electrical machinery industries. Especially in the electrical machinery industry, Japanese firms were able to capitalize upon the dynamic nature of this industry and its central position in the

Table 6. Export performance of major Japanese industries
(Millions of United States dollars)

Industry	1951	1961	1971	1980	1990	2000
Chemicals	52	205	1,698	7,050	15,399	33,906
Metals	312	621	4,576	21,334	19,562	26,452
Non-electrical machinery	61	313	2,448	16,876	45,526	78,769
Electrical machinery	15	337	2,874	24,263	85,242	149,279
Transport equipment	30	455	5,269	34,370	71,827	100,428
Instruments	13	106	1,464	6,479	15,119	38,667
Subtotal (B)	483	2,037	18,329	110,372	252,675	427,501
Total exports (A)	1,355	4,236	24,019	129,248	286,965	479,247
Ratio (B/A)	0.36	0.48	0.76	0.85	0.88	0.89

Source: International Trade Statistics Yearbook, various years from 1951 to 2000, published by the United Nations Conference on Trade and Development (UNCTAD).

current technological paradigm (Freeman and Louçã, 2001), and used it as an engine of growth and a source of inter-industry spillovers.

4. Back to FDI and knowledge sourcing through closer international business ties in the post catch-up era

After being defeated and left with a devastated economy, Japan had successfully caught up with western countries within only a generation. Japanese industrial firms became highly competitive in the world, with about one in six of the world's largest firms coming from Japan. The successful catch-up of Japan has been attributed, to a large extent, to its achievement in the area of technology, as we have seen the growth in the number of United States patents by Japanese firms (table 5). Japanese patenting in the United States increased by more than 650 per cent during the period from the mid-1960s to the mid-1980s, far greater than any other industrial economy (Mowery and Teece, 1992). By the late 1980s, Japanese firms had become the acknowledged technology leaders in many advanced industries.

The primary contention we set out to establish in this section is that as the technological capabilities of firms become more advanced and as the environment for innovation becomes more globally interconnected, firms must rely increasingly on closer cross-border relationships for knowledge exchange that include FDI, and international inter-firm networks. With Japanese firms becoming technological leaders themselves, technology imports via licensing have become increasingly inadequate to keep them at the cutting edge of technological development. At the same time, in an increasingly globalized and knowledge-based economy in which technologies have become more complex, interrelated and locationally dispersed and differentiated with local pockets of expertise, firms are finding it necessary to tap into capabilities residing elsewhere to keep pace with the fast-developing technologies (Cantwell, 1989; Cantwell and Mudambi, 2005; Dunning, 1996a; Nohria and Ghoshal, 1997). The technology strategies of Japanese firms post-catch-up began to shift again to place more emphasis on outward FDI and overseas R&D investment.

The growing success and technological competitiveness of Japanese industries gave rise to a growth in outward FDI from the 1970s onwards. Table 7 shows the outward FDI stock of the major Japanese industries from the 1970s to the 2000s. As we can see, following the growth of corporate innovation, outward FDI began to take off by the late 1970s, and the growth of FDI stock was particularly rapid in the 1980s. Industry-wise, we see that again, electrical machinery took over the leading position in the total stock of outward FDI from the 1980s onwards.

Table 7. Stock of outward FDI in major Japanese industries
(Millions of United States dollars)

	1960	1965	1970	1977	1980	1984	1990	1995	2000	2004
Chemicals				1,369	2,626	3,849	10,940	18,784	37,568	73,767
Metals				1,051	2,619	4,805	10,308	18,783	37,566	74,081
Non-electrical machinery				513	894	1,619	7,932	10,958	21,916	43,319
Electrical machinery				843	1,579	3,234	20,360	26,016	52,032	103,221
Transport				538	979	2,746	10,880	15,143	30,286	60,034
Total	529	1,394	4,339	21,223	36,497	71,431	310,808	445,692	889,990	1,754,418

Source: *IRM Directory of Statistics of International Investment and Production*, Dunning and Cantwell, London, Macmillan, 1987; World Investment Directory, UNCTAD, 1992; and JETRO.

Realizing the importance of global technology sourcing, Japanese firms began investing intensively in R&D sites abroad. Japanese R&D investments overseas have grown rapidly since the 1980s (e.g. Berry, 2006; Granstrand, 1999; Kogut and Chang, 1991; Iwasa and Odagiri, 2004; Pearce and Papanastassiou, 1996; Penner-Hahn and Shaver, 2005). According to Florida and Kenney (1994), as of 1990, Japanese corporations operated 174 stand-alone R&D laboratories in the United States alone and spent $1.2 billion on United States-based R&D, up from $307 million in 1987. Granstrand (1999) found that foreign R&D expenditures in selected leading Japanese corporations grew very fast, at a 48 per cent annual growth rate, over four times as fast as the annual growth of their total R&D expenditures (11 per cent), raising their foreign share of R&D expenditures from 1.58 per cent in 1987 to 5 per cent in 1991.

Empirical studies on overseas R&D by Japanese firms have found that knowledge sourcing is one major motivation for overseas R&D, particularly in the United States and Europe (Florida and Kenney, 1994; Granstrand, 1999). The R&D sites of Japanese firms abroad usually serve either or both of two purposes: to engage in product adaptation and to tap into the local science and technology base (Papanastassiou and Pearce, 1994). While demand considerations (i.e. to support local production and markets) are still important, creating access to foreign science and technology was the strongest driving force behind the increase in internationalization of Japanese R&D across sectors (Granstrand, 1999; Florida and Kenney, 1994; Freeman, 1987).

Similarly, Florida and Kenny (1994) found from their comprehensive data on Japanese R&D labs in the United States that although a large share of Japanese overseas R&D facilities are product development facilities that customize products for the local host country market and provide technical support to manufacturing, a smaller but significant number of Japanese overseas R&D investments are scientifically oriented basic research facilities, located near major research centres and universities. Their objective is to secure access to new sources of scientific and technical talent, and to harness the knowledge and ideas embedded in regionally based centres of innovation. It is these types of overseas R&D facilities that have engaged in active and effective knowledge sourcing (Belderbos, 2003; Todo and Shimizutani, 2005). They have tended to be heavily concentrated in technologically advanced industries such as electronics and automobiles, and many of them are located in regional innovation clusters, such as Silicon Valley in electronics and the Detroit area in automotive technology (Freeman, 1987; Iwasa and Odagiri, 2004).

However, despite the vigorous R&D investments abroad, innovation originating from overseas has played a minor role for Japanese firms (e.g. Belderbos, 2001; Patel, 1995; Cantwell and Zhang, 2006). Table 8 examines the share of United States patents of the largest Japanese-owned firms attributable to overseas research in the context of the world's largest firms from other countries of origin. Overall, the share of foreign-located R&D by Japanese-owned firms in the most recent period is only 1.08%, compared with the world average of 11.24%. Japan's low degree of internationalization has been unusual in comparison with the other industrialized economies, which Japan had caught up with long ago.

This unusually low degree of internationalization of innovation of Japanese-owned companies can be largely attributed to the particular institutional characteristics of Japan, most notably the Japanese system of innovation. It seems more difficult for Japanese firms to integrate R&D abroad with their core innovation networks at home because of the closely-knit R&D organization of these firms. Westney (1994) found that the Japanese system of innovation often involves the development of a domestic R&D network that runs even more extensively than usual (for large companies), beyond the boundaries of individual firms. Therefore, as Japanese-owned companies have expanded their networks across international borders, they have found that integrating offshore

R&D centres and foreign partners into these networks is more difficult than they had anticipated, partly because of the already complex system of innovation at home, and partly because they often need to involve the same set of domestic partners abroad.

The institutional environment also explains why Japan is such a minor recipient of inward FDI compared with other large economies. Japan's FDI outward stock in 2001 was about 6 times higher than its inward stock, and this gap has only been decreasing slightly since the mid-1990s (UNCTAD, 2006). In the period 1988–1990, only 1.4 per cent of the total FDI flows from the United States and EC countries went to Japan (Pearce and Papanastassiou, 1996, p. 6), and sales of foreign-owned firms in Japan around 1993 accounted for only 1 per cent or so its GNP, compared with 5 per cent or so in other advanced host countries such as France, Germany, the United Kingdom and the United States (Yoshitomi and Graham, 1996). The main reason is that inward FDI into Japan was severely restricted during the post-war years, and this policy has only been relaxed since the 1990s, associated with an increasing

Table 8. The share of United States patents of the world's largest firms attributable to research in foreign locations, organized by the nationality of the parent firms, 1969–1995

(Percentage)

Country	1969-72	1973-77	1978-82	1983-86	1987-90	1991-95
United States	4.91	5.88	6.41	7.54	7.91	8.63
Germany	12.77	11.05	12.07	14.47	17.05	20.72
United Kingdom	32.27	33.41	32.95	37.76	39.95	43.01
Italy	13.39	16.03	13.85	12.59	11.14	16.47
France	8.16	7.74	7.17	9.19	18.17	33.18
Japan	2.63	1.88	1.22	1.26	0.93	1.08
Netherlands	63.07	57.32	55.60	61.78	59.52	62.79
Belgium	50.00	54.32	56.27	71.21	59.04	67.25
Switzerland	44.36	43.63	43.78	41.59	42.99	52.47
Sweden	17.82	19.90	26.20	28.94	30.60	42.42
Canada	41.19	39.30	39.49	35.82	40.12	43.96
Total, of all countries	10.03	10.67	10.55	11.02	11.24	11.24
For Reference: Comparison of Japanese-owned patents from research in foreign locations with the equivalent from both home and foreign locations						
Japan (patents from foreign locations)	210	343	284	392	442	771
Japan (total patents from both home and foreign locations)	7998	18278	23249	31169	47793	71212

Source: United States patent database compiled by Professor John Cantwell, with the cooperation of the United States Patent and Trademark Office.

realization that international business may be needed as a catalyst for the institutional changes required to help address the problems that had by then arisen in the economy (Ozawa, 2003). Apart from government restrictions, the low level of inward FDI can also be attributed to other specificities of the institutional environment in Japan, such as the industrial structure, the keiretsu influence and the wider pervasiveness of local inter-firm networks (Dunning, 1996b).

Table 9 presents the share of research activity undertaken by non-Japanese firms in Japan, i.e. the inward penetration of foreign-owned firms to undertake R&D in Japan. It shows the inward penetration from foreign-owned firms is generally very low in Japan, especially in those industries in which Japan is strong, such as electrical equipment, motor vehicles, and professional and scientific instruments, with shares standing at only 1.13%, 1.78%, and 0.67% respectively in the period 1991–1995. The exceptions are industries in which Japan has traditionally been weak, and Japanese policy is more encouraging in bringing in foreign firms to boost innovation in these industries, e.g. the pharmaceutical-biotech industry.

Table 9. The share of United States patents of the largest non-Japanese-owned firms attributable to research in Japan, as a proportion of the number due to research in Japan by all Japanese and non-Japanese large firms, organized by the industrial group of the parent firms, 1969-1995

(Percentage)

Sector	1969-72	1973-77	1978-82	1983-86	1987-90	1991-95
Food	6.84	3.80	8.51	2.55	5.74	3.75
Chemicals	5.56	6.92	5.30	4.01	3.64	6.38
Pharmaceuticals	6.80	11.75	13.70	15.07	19.40	24.94
Metals	3.81	2.82	1.84	2.21	2.77	1.68
Mechanical Engineering	7.41	8.97	5.77	4.97	5.93	2.30
Electrical equipment	3.63	2.16	1.23	0.99	1.29	1.13
Office equipment	11.80	24.85	13.27	17.95	11.15	17.41
Motor vehicles	0.46	0.19	0.74	3.04	3.35	1.78
Aircraft	100.00	100.00	100.00	100.00	100.00	100.00
Other transport equipment	2.70	0.00	0.00	0.00	0.00	0.00
Textiles	1.65	1.70	1.51	1.46	0.33	0.79
Rubber products	8.20	1.21	0.00	0.37	1.86	1.36
Non-metallic mineral products	1.56	0.55	0.23	1.46	1.42	0.95
Coal and petroleum products	39.62	13.87	34.57	10.81	15.78	17.00
Professional and scientific instruments	0.33	0.06	0.10	0.30	0.43	0.67
Other manufacturing	5.79	10.16	3.16	4.95	14.50	91.32
Total	4.57	4.29	2.99	3.19	3.04	3.85

Source: United States patent database compiled by Professor John Cantwell, with the cooperation of the United States Patent and Trademark Office.

5. Concluding remarks

Before concluding, we are reminded that in describing and theorizing about what happened in the past, we need to appreciate that history is always to some extent unique, made up of a number of complex and contingent factors. While there are certain lessons that might be drawn from past events, we need to resist the temptation to over-theorize or prescribe recommendations for the future using past evidence. We need to be aware that specific historical periods and national business contexts have elements of distinctiveness. With this caveat in mind, we may draw the following inferences from the illustrative examples we have considered in this paper:

(a) International business connections are extremely important for firms in countries catching up and learning new technologies. We have seen how, in the interwar period, Japanese firms and the Government of Japan lured foreign firms to invest in the country, so that these foreign-owned firms could help train indigenous firms through joint venture or supplier or other local contractual relationships, as well as through the knowledge spillovers they generate. We have also seen how the nature of Japanese firms' international business connections shifted from being close in the interwar period (involving a foreign presence in Japan), becoming looser in the early post-war period (through arm's- length cross-border technology imports via licensing), and then reverting to being close again once capabilities had caught up (through outward and inward FDI, incorporating R&D).

A critical difference between the earlier catch-up of Japanese firms and firms in a late-industrializing country today is that countries such as Japan and the Republic of Korea caught up in a broad range of industries and technologies, while countries catching up more recently, especially East Asian countries, tend to be part of global supply chains. Modularization and fragmentation of the value chain and the consequent specialization of firms in certain segments of the value chain have made developing countries a critical part of a global production process. Hence, an inherent international connectedness of production activities is central to the catch-up efforts of today's emerging economies, in contrast to the experience of Japan and the Republic of Korea.

(b) A further general pattern is that international business connections are significantly more important during the very earliest stages of a successful development experience. This applies both to developing countries today and Japan historically. Firms first develop basic capabilities through local initiatives that may, especially in more established or mature industries, incorporate imitation and adaptation of products and technology transfer from foreign companies (Athreye and Cantwell, 2007). The further progression of such capabilities depends upon intensive in-house firm-specific learning efforts that are not easy or automatic but rely on deliberately undertaken and costly strategies for capability upgrading (Lall, 2001), which ultimately may lead R&D efforts to more advanced and sophisticated capabilities. Modifying and re-combining technologies learned through interactions with firms based in the established industrialized countries usually relies in the first instance on relatively close forms of international business connections. One example is the Japanese motor vehicle industry, which in the early stages might not have invented many "new to the world" products, since most of the technologies and prototypes came during the interwar period with the help of foreign firms. Yet this indigenous industry did make some original adaptations and set in train a process of internal learning that led eventually to more fundamental capabilities, and it was soon able to innovate to improve the production process and efficiency of factory operations.

(c) As Japanese firms caught up with those in western countries in technological capabilities, arm's-length cross-border technology imports via licensing became increasingly insufficient, and Japanese firms tried to forge more direct and closer international business connections via outward and inward FDI and R&D. Many Japanese scholars and officials themselves have come to appreciate this and are calling for Japan to be more open and to allow international connections to facilitate innovative regeneration (Ozawa, 2003; Best, 2000). Former Prime Minister Shinzo Abe appointed Mr. Kiyoshi Kurokawa, a medical professor, as special innovation advisor to head the Government's Innovation 25 initiative. Realizing that "Japan must join the world before it can lead it", the initiative set out to reform dramatically Japan's rigid structures of scientific education, funding and decision-making, and also to open up to international interaction, in order to boost technology and innovation in the country. Professor Kurokawa has been retained as the science advisor by the current Prime Minister (at the time of writing) Yasuo Fukuda, and many of the recommendations coming from Innovation 25 are being gradually implemented (Red Herring, 2007).

In closing, we may note that institutional reform in Asia has increased international business connections in many economies. However, Lall (2001) commented on how different forms of international business associations have prevailed across Asian countries that have been successfully catching up in technological capabilities. In other words, there is more than one potentially viable model for an effective relationship between international business connections and local capability-building. Singapore, in which FDI has made a highly dynamic contribution to local technological development, has been at the opposite extreme to Japan or the Republic of Korea in this respect. Which model is best suited depends upon the national political and institutional context, and on the extent to which foreign-owned firms can legitimately become embedded within domestic business networks, and hence become regarded as an integral part of the national business or innovation system. What we have stressed here is that, when viewed in a longer-term perspective, what is regarded as the appropriate model for the relationship between international business connections and technological capability development in indigenous firms tends to evolve over time, as the context or setting for international business connections shifts. The experience of Japan in this respect has helped us to explain the circumstances under which we observe different models of international business connections, and why and how indeed each of these may have its place.

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