3. The latecomer firm

3.1 ANALYTICAL FRAMEWORK

This chapter develops a simple analytical framework for assessing the experiences of the four dragons in electronics in subsequent chapters. A set of arguments are put forward as to the nature of latecomer firms and how East Asian companies were able to close much of the gap in electronics technology. The chapter holds that to overcome their barriers to entry, latecomer firms would need to progress simultaneously on two fronts: export marketing and technology. It is likely that successful companies would pursue strategies to link their export sales to technological learning and innovation.[1] Historically, this is likely to occur through a variety of stages requiring the deployment of various learning mechanisms. The simple model suggests how technological learning occurred as NIE firms graduated from the manufacture of simple goods to the design and development of complex electronics for export markets.

3.2 DEFINING TECHNOLOGY AND LEARNING

Schmooker (1966 p. 18) defined technology as the social pool of the industrial arts. Technology is a resource embodied not only in physical capital but, equally importantly, in human skills, institutions (especially firms) and social structures. Technology represents the capacity to create and extend the existing pool of industrial skills and knowledge. It is not a given or static resource, but rather a dynamic capability used to absorb, adapt and advance existing know-how and skills. Technology acquisition occurs when some or all of the skills needed to absorb and adapt a specific production process or product have been developed.

Technological learning is the process by which firms acquire technology. It is the 'what goes on' in the black box of the conventional (neoclassical) firm of economic theory. Put another way, learning refers to the mechanisms and processes by which technological progress is brought about. As Malerba (1992) shows, learning is central to productivity growth and different types of product and process improvement. Learning is clearly at odds with conventional economic ideas of learning-by-doing which treat technology accumulation as a passive, costless and automatic activity, usually plugged into a production function (Arrow 1962). In contrast with conventional learning-by-doing, technological learning is a dynamic, difficult and costly process. It normally involves substantial and deliberate effort and investment on the part of firms. Learning enables firms to build up their knowledge about products and manufacturing processes, and to develop, deploy and improve the skills of their workforces (Dodgson 1991 p. 23).

Learning is difficult to observe, accurately measure or indeed to distinguish from other manufacturing activities. Corporate learning, as with the learning of individuals, is difficult to analyse, although the outcome of successful learning can be dramatic in effect. The learning process is often a qualitative, informal activity, idiosyncratic in nature, cumulative in effect and uncertain in outcome. Learning usually involves both knowledge and experience, encompassing formal methods such as training and informal mechanisms such as imitation. Learning is usually costly and often difficult to undertake, but it is central to incremental technical change and corporate progress.

This study uses interviews with company directors and engineers to capture the nature of latecomer firm learning and to provide insights into the depth, timing, mechanisms and determinants of learning. The aim is to generate a qualitative understanding of the extent of learning among East Asian firms, over time. The intention is to identify the mechanisms by which firms accumulated technology in electronics, entered international markets and, in some cases, caught up with Western and Japanese market leaders.

3.3 LATECOMERS, LEADERS AND FOLLOWERS

Although learning has been central to technological progress (Fransman and King 1984), there is little analysis of how firms in latecomer countries deploy strategies to learn technology. Since Gerschenkron's classic works on patterns of nineteenth-century European industrialization, many studies have examined the general phenomenon of latecomer industrialization.[2] However, apart from Amsden (1989) and a few other studies, the contribution of firms, their origins, strategies, structures and methods for acquiring technology are rarely treated in the latecomer literature. It is therefore useful to define a latecomer firm and ask how it might develop its marketing and technological capabilities.

For the purposes of this study a latecomer firm is defined as a manufacturing company (existing or potential) which faces two sets of competitive disadvantages in attempting to compete in export markets. The first is techno-

logical in character. Located in a developing country, a latecomer firm is dislocated from the main international sources of technology and R&D. It operates in isolation from the world centres of science and innovation and is behind technologically, lacking in research, development and engineering capability. Its surrounding industrial and technological infrastructure is poorly developed. Local universities may also be weak technologically and other educational and technical institutions poorly equipped.

Normally, access to technology and a healthy surrounding national system of innovation is assumed to be essential for corporate competitiveness (Nelson and Rosenberg 1993). To succeed in international markets, the latecomer firm must overcome its technological disadvantages.

The second disadvantage concerns international markets and demanding users. To add to its technological difficulties, the latecomer firm is dislocated from the mainstream international markets it wishes to supply. These are mostly located in the advanced countries, rather than developing countries. Typically the firm will confront underdeveloped, small local markets and unsophisticated users. Many studies show the importance of user–producer linkages and clustering to innovation and industrial development.[3] To succeed, the latecomer firm has to devise ways of overcoming market barriers to entry and then to forge the user–producer linkages which stimulate technological advance. Based in a developing country, the latecomer has to develop outside the major international clusters of innovative suppliers and users.

Latecomer firms are clearly different from leaders. Technology leaders generate new products and processes to gain leadership advantages in the marketplace. Unlike a latecomer, a leader typically has a substantial R&D department capable of generating new innovations and contributing to the firms' competitive advantage. A leader may also enjoy strong and useful connections with universities and other parts of the surrounding technological infrastructure (e.g. IBM and Intel in the US). Through their capabilities, leaders contribute directly to the technological and scientific frontier in their field.

Latecomer firms are also distinct from technology followers.[4] Followers may be behind the leaders, but like leaders they are connected directly into the advanced markets in which they compete. Indeed, in some circumstances, fast followers may have advantages over leaders. They will have substantial technological resources to learn rapidly from the leader's experience, to avoid some of the R&D costs through imitation, and to adapt a product or process more closely to a buyer's need.[5] For example, Fairchild was the leader in the 8-bit microprocessor, but it lost its lead to followers Zilog, Intel and Motorola who introduced improvements to the basic Fairchild design (Langlois et al. 1988 p. 115). As Freeman (1974 p. 176) points out, followers will deploy their R&D resources to profit from the mistakes of others.

Latecomers do not have leader and follower advantages because they are weak technologically and isolated from advanced users. However, latecomers have substantial cost advantages over leaders and followers, and this can form part of their initial market entry strategy. The overall challenge confronting the latecomer is how to devise and implement corporate strategies which enable them to overcome initial market and technological barriers to entry, and then to acquire technology and increase export sales.

3.4 TECHNOLOGY ACQUISITION CHANNELS

Latecomer learning of foreign technology has become embedded in a variety of institutional channels which usually involve foreign firms in contractual arrangements in return for a particular service, such as low-cost production. These channels, presented in Table 3.1 evolved through time as latecomers sought to acquire complex technologies and to compete nearer the technology frontier. The channels, some of which overlap, apply to lesser or greater extents to each of the dragons.[6] Together, they enabled latecomers to acquire technology and enter export markets.

Table 3.1 Mechanisms of foreign technology acquisition by latecomer firms

Foreign direct investment (FDI)
Joint ventures
Licensing
Original equipment manufacture (OEM)
Own-design and manufacture (ODM)
Sub-contracting
Foreign and local buyers
Informal means (overseas training, hiring, returnees)
Overseas acquisitions/equity investments
Strategic partnerships for technology

Source: See text.

FDI and joint ventures were an important starting point for electronics, sparking off new export lines and leading to sub-contracting and OEM. As Schive (1990) and Fok (1991) show, foreign firms acted as demonstrators for local firms to imitate, some assisted local firms to grow through sub-contracting and licensing agreements. Many hired and trained locals in their subsidiaries. While the overall contribution of FDI to capital formation in South

Korea and Taiwan was small (James 1990 p. 11; Dahlman and Sananikone 1990 p. 73), it accounted for a disproportionately large share of electronics exports and employment. In Taiwan the TNCs gave rise to a Schumpeterian process of imitation and swarming on the part of local firms. In some cases, TNCs trained local firms to supply goods under sub-contracting relationships. Several latecomer companies gained direct access to training and engineering support under joint ventures, including Samsung Electronics and Tatung.

Under licensing arrangements latecomers pay for the right to manufacture products usually for the local market, and the TNC transfers the necessary technology for manufacture. Generally, licensing requires more technical capacity than a joint venture where often the senior partner trains the latecomer to manufacture. In Taiwan, between 1952 and 1988 the government approved more than 3,000 licensing agreements (mostly in electronics), many including formal technology transfer clauses (Dahlman and Sananikone 1990 p. 78).

Foreign and local buyers were also an important source of technology and market information in the four NIEs. Hone (1974) shows that many local firms initially sold their goods to large buying houses from Japan and the US. Foreign buyers often placed orders for 60 per cent to 100 per cent of the annual capacity of exporting firms in sectors such as clothing, electronics and plastics. The Japanese buyers (e.g. Mitsubishi, Mitsui, Marubeui-Ida and Nichimen) located in the NIEs to purchase cheap goods as wages rose in Japan in the early 1960s. During the late 1960s they purchased more than US$1.4 billion per annum of low-cost East Asian manufactured goods, 75 per cent of which were sold to the US. This led to a stream of Japanese manufacturers to Taiwan, South Korea and Singapore. Many US retail companies (e.g J.C. Penney, Macy's, Bloomingdales, Marcor and Sears Roebuck) followed suit (Hone 1974 p. 149).

The buyers enabled many firms to expand their production capacity and obtain credit against guaranteed forward export orders. Wortzel and Wortzel (1981), discussed below, show how some NIE exporters progressed from passively selling low-cost production capacity to actively promoting their services to new buyers and setting up marketing offices at home and abroad. Foreign buyers assisted latecomers into export markets and supplied technology in various forms. Often from local offices, they provided latecomers with information on product designs as well as advice on quality and cost accounting procedures. The largest buyers visited factories frequently and supervized the start-up of new operations. Some assisted with the purchase of essential materials, capital goods and components.

A study by Rhee et al. (1984) shows that around 50 per cent of firms in South Korea (from a sample of 113) benefited directly from buyers through

plant visits by foreign engineers and visits by Koreans to overseas factories. The buyers provided local companies with blueprints and specifications, information on competing goods and production techniques, as well as feedback on design, quality and performance. About 75 per cent of firms received assistance with product design, style and detailed specifications. In electronics, US retail chains and importers were the most important buyers during the 1970s in South Korea. Buyers helped the latecomers to overcome their distance from the advanced markets and foreign sources of technology.[7]

OEM (a specific form of sub-contracting) evolved out of the joint operations of buyers and latecomer suppliers and became the most important channel for export marketing during the 1980s. Under OEM, the latecomer produces a finished product to the precise specification of a foreign TNC. The foreign firm then markets the product under its own brand name, through its own distribution channels (thereby capturing the post-manufacturing value-added), enabling the latecomer to circumvent the need for investing in marketing and distribution. OEM often involves the foreign partner in the selection of capital equipment and the training of managers, engineers and technicians as well as advice on production, financing and management. In South Korea, OEM is sometimes linked to licensing deals. Successful OEM arrangements often involve a close long-term technological relationship between partner companies, because the TNC depends on the quality, delivery and price of the final output.[8]

OEM is also to be contrasted with own-design manufacture (ODM), first reported by Johnstone (1989 pp. 50–51). The nature and complexity of the OEM system evolved considerably during the early 1980s. According to Samsung, Anam, RJP and other firms analysed in this study, many of the electronic systems purchased under OEM were designed and specified, as well as manufactured, by the local firm rather than the TNC. In 1988 and 1989 this system began to be called ODM in Taiwan. At the time of this research the term ODM was not used by South Korean or Hong Kong firms. However, they too claimed that in many cases equivalent progress had taken place.

Under ODM the latecomer carries out some or all of the product design and process tasks needed to make a product according to a general design layout supplied by the foreign buyer (often a TNC). In some cases the buyer cooperates with the latecomer on the design. In other cases the buyer is presented with a range of finished products to choose from, defined and designed by the latecomer firm with its own knowledge of the international market. The goods are then sold under the TNC's or buyer's brand name as in OEM. ODM signifies the internalization of system design skills, and sometimes complex production technologies and component design abilities on the part of the latecomer.

ODM offers a mechanism for latecomer firms to capture more of the value-added while still avoiding the risk of launching own-brand products. Under early forms of OEM, the latecomer was confined to value-added related to assembly services. Under ODM the local company adds value in production engineering and product design. ODM indicates an advance in technological competence, although it is applied mainly to incremental (follower) designs, rather than leadership product innovations based on R&D.

However, as the country chapters show, the OEM system has several disadvantages. Strategically, the latecomer partner is often subordinated to the decisions of the buyer, and often dependent on the foreign company for technology and components as well as market channels. The TNC sometimes imposes restrictions on the activities of the OEM supplier. Without their own distribution outlets, the post-manufacturing value-added is limited. Also the system makes it difficult for local companies to build up the international brand images needed for high quality goods.

Despite the problems inherent with OEM and ODM, it would be wrong to understate the importance of the system. It facilitated rapid industrial growth in electronics and permitted the assimilation of technology. In some cases the more restrictive clauses on OEM and licensing were renegotiated. For example, marketing restrictions on mature products were often set aside so that South Korean firms could sell directly into third countries. The system allowed many companies to achieve economies of scale in production and, in some cases, to justify investments in automation technology. For their part, foreign TNCs continued to benefit from low-cost capacity expansion, enabling rival TNCs to compete with each other. OEM therefore endures as a mutually valued arrangement.

Alongside the formal mechanisms for technology transfer many informal channels exist. These include the hiring of foreign engineers and the recruiting of locals trained in foreign TNCs. Many East Asian engineers went abroad for training in foreign companies, universities, colleges and R&D institutes. As Dahlman and Sananikone (1990) show for Taiwan, informal sources of technology included the copying of products, reverse engineering and the widespread training of foreign engineers abroad. The flow of technically trained Taiwanese returning to Taiwan rose from around 250 in 1985, to 750 in 1989 and more than 1,000 in 1991.[9]

As latecomer firms grew in size and competence, overseas investments became another means of acquiring foreign technology. Companies such as Samsung and Hyundai purchased several high technology firms to acquire skilled engineers and equipment. Strategic partnerships (i.e. joint ventures on a more equal footing) also enabled latecomers to enhance their technological capabilities by developing a new product or process jointly with a foreign company. Samsung, for example, jointed an eight year agreement with Toshiba

of Japan in 1992 to develop flash memory chips and with Texas Instruments (TI) to make semiconductors in Portugal in 1993 (*Fortune* 3 May 1993 p. 28).

To sum up, each of the foreign technology channels in Table 3.1 were exploited by latecomer firms to learn skills and overcome barriers to entry into export markets. Most of the mechanisms were dual purpose, providing market and technology access. As the case studies below show, latecomers worked to couple technological and market opportunities, using market signals as a focusing device for technological learning. Over three decades or so, this coupling process has resulted in a substantial, if largely incremental, innovative capacity on the part of many latecomers.

3.5 THE SIMPLE MODEL

As noted above, Wortzel and Wortzel (1981) put forward a simple marketing scheme to show that NIE exporters graduated from supplying labour-intensive assembly services to exporting advanced goods into foreign markets. Their study is based on interviews with locally owned firms in three Asian dragons (South Korea, Taiwan and Hong Kong) as well as Thailand and the Philippines. It is one of the only studies which systematically analyses the export marketing strategies of firms in East Asia. Their study covers three export industries: consumer electronics, athletics footwear and clothing.

Wortzel and Wortzel were not concerned with the technology dimension of firms' development. However, as argued below, it is likely that as firms accumulated marketing skills they also learned technology skills in order to meet increasingly sophisticated customer needs and to capture more of the post-production value-added.

The left-hand column of Table 3.2. summarizes Wortzel and Wortzel's five-stage marketing model. The latecomer firm progressively internalizes the marketing skills and functions initially carried out by the foreign buyer or manufacturer. In the first stage the latecomer is entirely dependent upon buyers for product design skills, marketing, distribution and quality control, while the local firm supplies low-cost production capacity. As the model indicates, during stages two to five the latecomer firm assimilates more and more complex marketing functions. Spurred on by the prospect of growth and profit opportunties, the firm learns how to conduct its own sales and marketing. It progressively broadens its range of customers and improves the packaging and quality of its products.

By stage five the latecomer firm will have developed its own brand design and will organize its own sales either directly to customers overseas or through distributors. No longer is it dependent on the distribution channels of

quality and speed of production. During the early stages, firms are likely to remain dependent on outside sources for technology.

Soon, technicians will begin to internalize key production skills. Eventually, the latecomer firm will gain more and more control over its production processes, spurred on by export market opportunities. By acquiring product and process capabilities it will be able to sell higher quality products to a larger base of customers, bringing the advantages of low-cost engineering and management to the market.

The latecomer entrepreneur recognizes that unless the firm goes through a series of difficult technology learning transitions it will remain trapped in the capacity export stage. By stage four, the firm's strategy will be directed to strengthening the skills needed to develop new products and processes. The latecomer will have surmounted its technological dependency in terms of product design, quality control and process engineering. It may have already forged links with capital goods suppliers and may conduct R&D into new products and processes.

The final phase, stage five, is currently of great interest to South Korean and Taiwanese latecomer firms. By reaching this stage they will have developed advanced marketing skills and R&D capabilities, overcoming their latecomer status. At this stage they would be indistinguishable from world market leaders and followers and will be capable of competing at the technology frontier. However, if they fail to progress to these higher stages of product and process development they will presumably retain, at least in some respects, latecomer structures and orientations. This is a theme examined in each of the country chapters.

3.7 LINKING TECHNOLOGY TO THE MARKET

In the simple model, the technological role of exports is to progressively pull the learning of latecomer firms forward by stimulating technological change. Through sub-contracting and other channels, export clients and export demand act as a focusing device for technological investments. Exports force the pace of technological progress and enable latecomers to overcome their distance from the demanding markets of the West. Local competition stimulates the process as export leaders are imitated by followers.

There may not always be systematic, causal links between the stages of technology and market development. It is theoretically possible for a firm to acquire advanced technological skills but still remain at the early stages of marketing – or *vice versa*.

However, it is likely that latecomers will tend to improve both their technology and marketing capabilities simultaneously. Marketing skills are needed

for firms to capture the added value associated with packaging, distribution, brand awareness and after-sales service. Marketing capabilities assist firms to expand their range of customers and control the direction of their future business. Similarly, technological know-how is needed to develop new products and improve the efficiency of production. Firms have an incentive to expand their profit opportunities, to manage and reduce their dependency on foreign sources and to respond to competition from other latecomers. These processes require the internal acquisition of both marketing and technological skills.

In some of the stages there may be a direct link between market and technology. For instance, when shifting from stages one to two, firms will need to internalize process skills to expand production capacity, shorten delivery times and improve product quality. To maximize sales of production capacity to key customers, joint engineering work may be needed. Later, to achieve the advanced stage of product marketing push, firms will need sufficient R&D capabilities to convert market signals into innovative new products.

Furthermore, the channels for technology transfer and marketing may be one and the same, as with sub-contracting and OEM/ODM. As the country chapters show, under sales and exporting arrangements latecomer firms are often presented with a technology transfer mechanism. For instance when sub-contracting, the latecomer is often supplied with technical specifications, training and advice on production and management by the TNC. The motive of the TNC is to ensure quality, delivery and price of the final output. These propositions are explored in depth in the individual cases of corporate learning.

3.8 LATECOMERS AND INNOVATION THEORY

According to the simple model above, latecomer firms will tend to enter at the mature, standardized end of the product life cycle. This runs in contrast with the traditional technology life cycle models put forward in evolutionary Western models of innovation.[10] The latter have related empirically observed product life cycles (PLCs) to configurations of product and process technologies (e.g. Utterback and Abernathy 1975; Abernathy et al. 1983). These studies argue that the stage of evolution of a new product is intimately related to process and product innovations.

According to the standard Western model, at the early stage of the PLC, the rate of product innovation is high. Process technology will be relatively experimental and uncoordinated. Products undergo intense innovation, stimulated by market needs. At this stage product markets are ill-defined and non-standard. As a product is successful in the market place a dominant design (i.e. a standard) emerges, sales increase and market uncertainty diminishes.

Eventually, a product will reach a stage where competition is based largely on price and cost minimization. At this mature phase of the PLC, manufacturing processes tend to become standardized and innovation becomes incremental rather than radical. There is also a shift from the early uncertainty over the technology towards a greater understanding and agreement on market and technological requirements.

Once a dominant design emerges, small uncompetitive firms exit or are acquired by large companies. Eventually, a small number of firms come to dominate the industry by exploiting scale intensive, incremental process improvements. As Utterback and Suarez (1993 pp. 2–3) state: 'Eventually, we believe that the market reaches a point of stability in which there are only a few large firms having standardised or slightly differentiated products and relatively stable sales and market shares, until a major technological discontinuity occurs and starts a new cycle again.'[11]

Although innovation is not a linear process from the R&D laboratory to the market, the creation and diffusion of new technologies are distinct activities: the R&D lab develops, the market selects (Utterback and Abernathy 1975). The outcome of the competitive contest tends to be traceable to the competences, skills and complementary assets that the various rivals bring to the marketplace (Teece 1986). Products and industries undergo life cycles from fluid immaturity states to maturity (Abernathy and Utterback 1979; Kotler 1976). Cycles can cover long periods of gradual evolution, punctuated by short periods of disruptive change (Tushman and Anderson 1986).

3.9 PRODUCT LIFE CYCLES AND LATECOMER FIRMS

The standard model of industrial innovation is intimately linked to the production paradigm of large-volume commodity goods, such as the electronics exports of East Asian firms. However, in contrast with the standard theory, according to the latecomer model above, latecomer firms tend to enter at the mature, standardized end of the PLC and gradually assimilate technology by learning. Latecomer firms are likely to enter at the point where production processes are standardized and cost minimization is paramount. With each wave of new innovations they catch up little by little, closing the technology gap between themselves and the market leaders. In this sense, latecomer firms travel backwards along the PLC. More precisely, with each new wave of product innovations, latecomers move closer and closer to the early activities associated with the early stages of the PLC.[12]

Here, the proposition is that the exporting NIE firm learns its way from the latter stages of technological development to the early stages, working back from the standardized market and technology stages to the more uncertain,

early design-intensive and complex innovation stages. During stages one and two, the latecomer will engage with the mature phase of a product's development, focusing on cost minimization as the core competitive strategy. The NIE exporter is able to offer lower costs of production, based primarily on low wage rates. This attracts the attention of buyers, distributors, wholesalers and manufacturing firms in the Western markets, some of whom establish themselves in the NIE.[13]

From the perspective of technological learning, in stage one the NIE firm will begin to build up its basic production capabilities during the course of manufacturing (simple learning by manufacturing). In stage two the company acquires some minor incremental process capabilities, moving backwards along Utterback and Abernathy's model.

The latecomer firm will begin to acquire some control over the quality and speed of production, but is likely to remain dependent on outside sources for process technology. Local technicians are likely to be trained to ensure the internalization of production process technology (learning by incremental process innovation).

The first two market stages of Wortzel and Wortzel correspond to the entry and acquisition of standard process technology. Stage three of Wortzel and Wortzel relates to the more malleable production stages where product design becomes increasingly important. At this stage the latecomer company gains far more control over production process technology. It will have developed considerable product design skills.

In stage four, the firm approaches the product innovation stage. The latecomer will have gained sufficient skills and human resources to develop new products and the new processes needed to make the new products. Strategies will focus on surmounting any remaining technological dependency on outside companies for product design, quality control and process engineering. The firm may well have forged upstream links with capital goods suppliers and may conduct R&D for new products.

Finally, in stage five, the company is as technologically advanced as a leader or follower. The latecomer will carry out R&D for products and processes in competition with Western and Japanese TNCs. Strategies will focus on developing highly complex product and process innovation skills, while proactive R&D will be directed to push the technology frontier forward. By reversing the traditional path of technology development, the firm will have graduated from the mature to early stages overcoming its distance from the world technology frontier. The strategy of linking technology to the market enables the firm to compensate for the lack of demanding local users and consumers.

3.10 INNOVATION, IMITATION AND LEARNING

One of the aims of this study is to assess whether or not latecomer firms innovate and, if so, in what sense do they innovate. To examine this question it is first helpful to introduce some basic definitions. Process innovation is usually defined as a technological change which reduces the cost of making an existing product or enhances the quality or performance of an existing product. By contrast, a product innovation involves the development of a new or improved good.

According to most Western studies, the acid test of an innovation is the successful introduction of a new or improved product to the marketplace (or the commercial use of a new manufacturing process) (Dorfman 1987 p. 4; SPRU 1972 p. 7; Kamien and Schwartz 1982 p. 2). However, this strict definition, although useful for research into leaders and followers, fails to capture important industrial and corporate transformations which occur on the part of latecomers. The latter firms, almost by definition, function from behind the technology frontier. Therefore, following Myers and Marquis (1969), Schmookler (1966) and Gerstenfeld and Wortzel (1977 pp. 59–60), this study defines innovation as a product or process new to the firm, rather than to the world or marketplace. When a company produces a new good or service or applies a new method or material it makes a technical change and an innovation can be said to have occurred. As Myers and Marquis argue, many firms have been profoundly altered by innovations new to the company, although not new to the world (cited in Gerstenfeld and Wortzel 1977 p. 60). As shown later, this broad definition helps capture the nature of innovation in East Asia.

In addition, the definition used in this book does not make a stark distinction between innovation and imitation. Imitation is often misinterpreted as the demonstration of a lack of creativity and talent. However, confirming the importance of imitation in their study of Japanese industrial development, Abegglen and Stalk (1985 p. 146) cite from Professor Harvey Brooks of Harvard University, addressing a US House Subcommittee on Science and Technology:

> history suggests that imitation, followed by more and more innovative adaptation, leading eventually to pioneering, creative innovation forms the natural sequence of economic and industrial development. Successful imitation, far from being symptomatic of lack of originality as used to be thought, is the first step of learning to be creative.

This study therefore pays special attention to learning to imitate as well as learning to innovate with new products and processes.

Innovation is often a long-term process, rather than a once-and-for-all change. Toyota began their development of the now-famous just-in-time (JIT) car production system in the late 1930s. Under Mr Taiichi Ohno and his associates, during the 1950s and 1960s, Toyota introduced a large number of minor, often difficult improvements (Abegglen and Stalk 1985 pp. 93–104). Yet, it was only in the 1980s that the JIT system reached the eyes and ears of most Western observers.

The JIT innovation example also shows the manner in which innovation is often bound up with non-technological factors. As well as pushing and shoving on a variety of engineering fronts, the JIT system required continuous organizational re-thinking and change. Factory layouts had to be changed. Great efforts had to be made to connect up each of the sub-assembly and fabrication steps, so that material flowed quickly to final assembly lines and inventories could be eliminated.

Another lesson from the Japanese experience is the importance of minor, continuous improvements and the contrast between radical and incremental innovation. A radical product innovation in electronics would, for instance, be the introduction of a brand new, successful product such as the Sony Walkman or the camcorder. By contrast, an incremental innovation would be a minor improvement to the design of a product already on the market. Similarly, a radical process innovation would for instance be the introduction of a new CAD/CAM system. An incremental or minor process innovation would include the modification of production equipment or the improvement of an existing material. In their study of innovation in Japan, Abegglen and Stalk (1985 p. 146) show that Japanese industrial success was based largely on the continuous and creative adaptation of Western, mainly American, technology.

Learning to innovate is therefore a long-term process which cannot be captured solely by counting discrete innovations. In the country case studies careful attention is payed to both technological and organizational innovation, as well as evidence of minor incremental technological change.

3.11 KEY RESEARCH QUESTIONS TO EXPLORE

One major problem in understanding East Asian innovation is the lack of empirical evidence to refute, validate or qualify the model presented above, or any other interpretation for that matter. Some evidence suggests that large buyers assisted latecomer firms to progressively internalize technological skills (Chaponniere and Fouquin 1989; Dahlman and Sananikone 1990). However, there is little analysis of the strategies of individual firms to show how the learning process occurred. Hopefully, the firm-level data on

corporate learning paths in the four NIEs will provide general insights into the question of latecomer learning.

One important set of questions concerns the latecomer entrepreneur. What was the origin of the latecomer? How did the firms initially enter international markets? This is an important issue for other developing countries wishing to emulate the success of the dragons. Once the firm entered the export market, how did it build up and strengthen its technological capability? What strategies towards learning and training can be discerned from the evidence on latecomer firms?

Following the logic of the simple model above, other interesting questions present themselves. Do early entrants tend to go through all the stages? Can the stages be carried out simultaneously? As the quality of the local infrastructure improves, can new entrants jump in at the later stages? If so where do they acquire their marketing and technology skills? How do changing factor costs and local market developments affect the strategies of the latecomers? How do firms acquire the skilled engineers, technicians and managers to adapt and improve electronics technology, assuming they do?

Do latecomer firms innovate as they catch up? If so what is the nature and pattern of latecomer innovation? What does innovation mean in the latecomer context? How do firms assimilate innovative capabilities while they are learning? Which factors trigger latecomer innovation? What, if anything, ensures that firms to go beyond keeping up to actually catching up? How do firms change their strategies as they approach the innovation frontiers in the later stages?

At the policy level, it would be useful to know what part East Asian governments played in helping to start up and strengthen their electronics firms. What were the similarities and differences in policy across the four countries and what lessons can be derived from the policy experiences of the NIEs? Which technological infrastructures need to be in place to ensure that widespread catching-up learning can occur?

Finally, at the strategic level, to what extent do latecomer firms represent a challenge to Japan now and in the future? Do latecomers still differ from followers and leaders? What are the current strengths and weaknesses of East Asian firms? Will they be able to overcome their remaining weaknesses to become fully fledged technology leaders?

The rest of the book seeks to answer these questions by examining technological learning at the industrial and firm level in the four NIEs. Illustrative examples of historical learning paths are used to show the patterns of technological transformation as companies moved on to more advanced stages of production. The book explores the learning interface between local firms and foreign buyers and TNCs. Finally, the study attempts to show how the latecomers are changing their strategies to meet new demands as they approach the innovation frontier in electronics.

NOTES

1. In this study strategy refers to the reality of its enactment, rather than in formal pronouncements or statements of intent. As Burgleman and Rosenbloom (1989 p. 19) argue, technology strategy refers to the manner in which technology is sourced, acquired, developed and deployed. The ways in which these tasks are performed contribute to the capability of the firm.
2. See Gerschenkron (1962). A review of latecomer industrialization and Gerschenkron's own contribution is provided by Sylla and Toniolo (1991). Vogel (1991 p. 5) categorizes the four dragons as late late developers. Amsden (1989) uses the latecomer concept to analyse South Korean development and shows how several large companies acquired technology.
3. See, for instance, Marshall's work on industrial districts (1890, ch. 10) discussed by Freeman (1990), Vernon's study on externalities (1960), especially ch. 5 'External Economies', Lundvall's (1988) study on user–producer interaction and Porter's (1990) study on the competitive advantage of nations.
4. As Freeman (1974 p. 269) argues, the idea of leader and follower makes most sense when referring to a firm's strategy in a specific product technology. A large firm may well be a leader in some areas and a follower in others. By contrast, firms from developing countries will tend to be latecomers across a broad range of product technologies.
5. For an analysis of follower and leader strategies see Ansoff and Stewart (1967), Freeman (1974, ch. 8) Porter (1985, ch. 5) and Teece (1986). Freeman's (1974 ch. 8) offensive and defensive strategies are broadly equivalent to the ideas of leadership and followership put forward by Porter and Teece.
6. It is beyond the scope of this study to compare their relative importance through time or across countries, to analyse how the mechanisms relate to each other. Comparing local with foreign sources is also a difficult task as the two are inextricably entwined, with local efforts being essential to absorb foreign technology. Dahlman and Sananikone (1990) provide an in-depth analysis for the case of Taiwan. Schive (1990) deals in depth with FDI in Taiwan.
7. Egan and Mody (1992) and *Forbes* (21 December 1992) show how US manufacturers and distributors purchased bicycles from Taiwan and transferred technology; eventually the Taiwanese succeeded in displacing most of their former American teachers.
8. OEM is similar to sub-contracting in semiconductors and other sectors (e.g. in bicycles and footwear; Egan and Mody 1992). The term OEM originated in the 1950s among computer makers who used sub-contractors (called the OEM) to assemble equipment for them. It was later adopted by US chip companies in the 1960s who used 'OEMs' to assemble and test semiconductors. Since then the term has acquired a variety of meanings. Some use the term to mean the final equipment maker (the TNC buyer), rather than the supplier or sub-contractor. To avoid confusion, in this book OEM refers to the system by which firms cooperate in sub-contracting relationships, rather than any particular buyer or supplier.
9. Official statistics cited in *Business Week* (30 November 1992 p. 76). In Taiwan former Bell Labs employees started the Taiwanese Bell Systems Alumni Association which had 120 members in 1992. Similarly in 1994 there were around 80 Bell Labs Alumni in South Korea. Hundreds of others had returned from Caltech, MIT and other leading US technology centres.
10. A critique of the method and data used in the original cross-industry study by Utterback and Abernathy (1975) is provided by Pavitt and Rothwell (1976). A general review of innovation models is provided by Forrest (1991). Metcalfe (1981) also provides useful critiques and extensions.

11. Their study is based on eight industries: manual typewriters, automobiles, electronic calculators, transistors, semiconductors, television sets, television tubes and parallel supercomputers. Note that, apart from supercomputers, these are all high-volume, mass-market industries, where incremental process improvements eventually determine competitive performance. As Pavitt and Rothwell (1976) point out, other types of industry may not follow this pattern.
12. A similar argument to this is put forward by Vernon (1966) for the case of TNCs in developing countries, rather than local firms. The view that latecomers might enter at the standardized end of the PLC is also suggested in a study of innovations made by 33 Taiwanese firms in the mid-1970s by Gerstenfeld and Wortzel (1977 pp. 57–68). This encompassed a range of industries but did not look at progress through time.
13. As Vernon (1966) argues for the case of TNC location decisions, in the case of a mature product and process, the advanced-country firm is freer to seek out lower costs and sources of supply in developing countries.

4. The Republic of Korea: catching up in large corporations

4.1 COMPRESSING THE CYCLE OF TECHNOLOGICAL LEARNING

Just 15 years ago, South Korea[1] had no substantial position in the electronics industry. By the early 1990s, three of the local conglomerates (known as *chaebol*) ranked among the largest electronics producers in the world. As a result of the strategies of the *chaebol* and other fast-growing local companies, production and exports of electronics outstripped steel, automobiles and most other industries by a wide margin during the 1980s.

This chapter explains how South Korean firms gained their competences and overcame barriers to entry, illustrating the forces that shaped and triggered the country's progress. Foreign channels of technology were exploited to the advantage of local firms as they learned production methods, reverse engineered products and accumulated design skills. By linking export demands with in-house investments in know-how, the *chaebol* quickly learned the technology of electronics.

The chapter shows how the government steered early industrial development through its policies and later took a less interventionist role as the *chaebol* grew. Illustrating the achievements of South Korea's latecomer firms in electronics, the chapter charts the growing strength of the *chaebol* through time, pinpointing remaining weaknesses.

Export growth was facilitated by institutional channels, especially OEM, which enabled the latecomers to systematically learn foreign technology. These channels evolved as local corporations compressed the cycle of learning through time.

Individual cases are used to show how latecomer firms transformed themselves into large, competent companies. The chapter illustrates the extent and nature of innovation among local firms, comparing development paths across a range of technologies.[2] Although their skill and tenacity enabled the latecomers to narrow the innovation gap, in some respects they remain latecomers, dependent on foreign competitors for brand names, core components and capital goods. Formulating strategies to overcome these limitations sets the agenda for South Korean firms through the 1990s and beyond.