Catching-Up, Crisis and Industrial Upgrading. Evolutionary Aspects of Technological Learning in Korea`s Electronics Industry

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Abstract

This paper addresses a puzzle: How is it possible that a country that has established a broad, export-oriented industrial base at record speed, remains vulnerable to the vicissitudes of international finance and currency markets? I argue that the Korean model that was tremendously successful for catching-up, has now reached its limits. The analysis centers on the co-evolution of industry structure and firm behavior. The focus is on the role of *technological learning* for the development of the electronics industry, a main carrier of Korea´s successful late industrialization. It is shown that a heavy reliance on credit and an extremely unbalanced industry structure have given rise to a narrow knowledge base and a sticky pattern of specialization. Catching-up has focused on capacity and international market share expansion for homogeneous, mass-produced products; very little upgrading has occurred into higher-end and rapidly growing market segments for differentiated products and services. Such *truncated upgrading* is one important reason for Korea´s vulnerability to the financial and currency crisis.

Key words

learning; innovation; catching-up; industrialization; industrial upgrading; industrial policies; electronics industry; financial crisis; Asia; Korea.

JEL classification
L16, L63, O12, O19, O33

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Contents

The Issue

Korea has been highly successful in its approach to industrialization: within three decades a resource-poor and relatively small country at the periphery of the world economy has become a leading exporter of manufactures; of all developing countries, Korea has experienced the most rapid expansion and transformation of its manufacturing sector; and a critical feature of the Korean model of late industrialization has been its focus on learning and capability formation (Kim Linsu 1997a). These achievements are real and very impressive.

Then, seemingly out of the blue, crisis hit: Korea´s currency tumbles, asset prices are collapsing, financial and corporate insolvency are spreading, and economic growth has been drastically reduced. There is a real danger that stagnation may last for a couple of years and that this may well destroy earlier achievements and accumulated capabilities. What went wrong with the Korean model? How is it possible that a country that has succeeded to establish a broad industrial base at record speed, remains vulnerable to the vicissitudes of international finance and currency markets? Does this imply that the Korean model of late industrialization has failed, that industrial policies have to be discarded and that a convergence to the Anglo-American model of capitalism is the only option left?[1]

The answer to these questions depends on how one explains the current crisis; of equal importance is how one defines the Korean model. A popular explanation of the crisis is that Korea´s real problem lies with banks and their regulation and has little to do with the real economy[2] ; others highlight the catalytic role played by the uncontrolled globalization of capital markets and the deflationary risks of the IMF´s rescue package[3]. Such explanations only provide an incomplete picture. There is no

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[1] See, for instance, Roberts, P.C., "The Asian Crisis Proves Industrial Policy Doesn´t Pay", Business Week, December 22, 1997, p.12. For a critique of such claims, see Chang Ha Joon (1998a and 1998b). The limits of convergence theory are discussed in Boyer, 1986 and other contributions in Berger and Dore (1996); and in Ernst and Ravenhill 1997.

[2] See for instance Krugman, 1998. For an earlier systematic analysis of such mechanisms in the case of Korea, see Kim Pyung Joo, 1994 and R.Z. Aliber, 1994.

[3] For an analysis of how the international financial system has acted as a catalyst for Asia´s current crisis, see Jomo, K.S., 1998. See also "Asia in Crisis. Financial Times Special Report", Financial Times, January 12-18, 1998. For a critique of the IMF approach, see Sachs (1997), Stiglitz (1997), and Veneroso and Wade (1998).

doubt that problems in Korea´s political economy have been closely interacting with financial factors in the making of the crisis.

A novel contribution of this paper is its analysis of some inherent limitations of the Korean model of late industrialization[4]. The focus is on the role of technological learning for the development of Korea´s electronics industry[5]. I argue that the Korean model that was tremendously successful during the catching-up phase, has now reached its limits for two reasons: it generates unsustainable high debt-equity ratios, and it is out of touch with current industrial upgrading requirements[6]. This implies that attempts to return to the status quo ante will not provide a solution; nor will the IMF approach with its focus on deregulation. While drastic changes in the financial system are important, they need to be supplemented with changes in the real economy: industrial upgrading is overdue, and this requires fundamental changes in the Korean model. This does not imply a weakening of the coordinating function of the state. Overcoming the barriers to industrial upgrading instead necessitates a redefinition and strengthening of policies and institutions that can provide the incentives and externalities that are necessary for technological learning[7]. The result is that national policy interventions are required that can compensate for these market failures. In addition to the subsidies and tax incentives, suggested by Arrow, this also implies a variety of organizational and institutional innovations in the implementation of government policies. A growing body of research on economic policy-making in advanced industrial countries has demonstrated that choice is possible, in terms of institutions and policy instruments, and that this applies to macro-economic policy-making as well as to industrial and

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4 My understanding of Korea has been shaped by numerous interviews that I have conducted in this country over the last two decades. I have also learnt a great deal from the writings of Kim Linsu, one of the most thoughtful observers of Korean development, and a number of (mostly Korean) authors that I have mentioned in the bibliography. Important sources on the Korean model include Johnson (1987), Amsden (1989), Wade (1990), Haggard (1990), Kim Linsu (1992 and 1997), Evans (1995), and Chang Ha-Joon (1994, 1998a, and 1998b).

5 The development of Korea´s electronics industry arguably has been the most impressive example of its successful late industrialization.

6 For earlier versions of this argument, see Ernst and O`Connor, 1989 and 1992; and Ernst, 1994b

7 Markets are notoriously weak in generating technological learning. They are subject to externalities: investments in capabilities are typically characterized by a gap between private and social rates of return(Arrow, 1962).

technology policies[8]. The same is true for developing countries. The real question then is no longer whether national policies can make a difference, but rather: What kind of policies and institutions are most conducive for improving local competitiveness?

The analysis is centered on four basic limitations of the Korean model that result from a symbiotic relationship between governments and large business groups (the chaebol): i) a heavy reliance on credit and ii) an extremely unbalanced industry structure have given rise to iii) a narrow knowledge base, and iv) a sticky pattern of specialization. Catching-up has focused on capacity and international market share expansion for homogeneous, mass-produced products; very little upgrading has occurred into higher-end and rapidly growing market segments for differentiated products and services. It is argued that such truncated upgrading is one important reason for Korea´s vulnerability to the financial and currency crisis.

The argument is developed in three steps: In part I, I present key features of the Korean approach to technological learning that were conducive for rapid catching-up. Part II addresses some major weaknesses. I review evidence on two indicators of truncated industrial upgrading: sticky specialization, and a narrow domestic knowledge base. I then discuss the role of two explanatory factors: Korea´s high-debt growth model and its unbalanced industry structure. In both parts, I use a comparison with Japan and Taiwan in order to highlight some peculiar features of the Korean way of technological learning. Finally, in the last part, I deal with the options for strategic response: I describe some new competitive challenges that Korea´s electronics industry is facing today and demonstrate why Korea can no longer afford to muddle through in a state of truncated upgrading. I then sketch out one possible option for strategic response to the current crisis: an upgrading from product to technology diversification that broadens Korea´s knowledge base, but at the same time utilizes its traditional strengths. I conclude with a brief discussion of changes that are necessary in order to remove the barriers to industrial upgrading.

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[8] For macroeconomic policies, see Frieden, 1991 and Fraenkel, Phillips and Chinn, 1992. For industrial and technology policies, see Berger and Dore (eds.), 1996.

I. Catching-Up in Electronics: Key Features of the Korean Approach to Technological Learning

I.1. Achievements

Korea´s performance in the electronics industry has been truly remarkable: from a meager $ 89 million in 1971, Korea´s electronics exports grew to $21.5 billion in 1996 (EIAK, July 1997); electronics is the country´s leading export industry; and Korean electronics firms have developed strong positions in a number of important international markets. They are the second largest supplier, behind Japanese firms, for a broad range of consumer devices, from audio equipment to CTVs, VCRs and microwave ovens, and for related key components (such as picture tubes) that require precision engineering. Korean firms also excel as leading suppliers of computer monitors and have recently developed a strong position in display technology[9].

Probably the most impressive achievement has been their meteoric rise in DRAMs[10]: within less than a decade, the three main Korean producers, Samsung , Goldstar (now LG) and Hyundai succeeded in eroding the once overwhelming dominance of Japanese producers[11]. Between 1988 and 1992, Korea´s market share for DRAMs increased from 7.5% to 17.7% in the U.S., from less than 7.8 % to 18.1% in Europe, and from 23.6% to 33.7% in Asia, exclusive of Japan[12] Today, Korea firms control roughly one third of the global market for DRAMs, well ahead of the 20% market share of American companies and large enough to induce a sea

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9 Asia IT Report, "South Korea´s Monitor Industry in 1996", Market Intelligence Center, Institute for Information Industry, Taipei, September 1997. See also Linden et al (1997).

10 DRAMs (= Dynamic Random Access Memories) constitute the largest market segment for computer memories and make up roughly 24% of the world´s total semiconductor demand (Dataquest, 1996)

11 Intel and other American firms like Texas Instruments and Motorola had originally created the DRAM market. However by around 1986, five major Japanese firms NEC, Toshiba, Hitachi, Fujitsu, and Mitsubishi) had taken over and had established a tight oligopoly that controlled roughly two third of the world market for DRAMs (Ernst and O´Connor, 1992, chapter II). Today, their share has fallen to below 48%, and this is primarily due to the successful market penetration by Korean firms..

12 Figures are courtesy of Dataquest, San JosÈ, California.

change in industry structure: the three Korean majors have now have become accepted members of the global oligopoly in this important market segment[13].

This success has been due to a single-minded dedication to the requirements of catching-up. How have Korean electronics firms developed their technological capabilities in the context of export-led industrialization, and what explains the speed of catching-up? A comparative perspective can help us to highlight some of the peculiar features of the Korean case: where appropriate, I will use a comparison with earlier developments in Japan and with some distinguishing features of the Taiwanese approach to technological learning. When Korea began to enter the international electronics markets in the late 1960s, its main concern mirrored that of the Japanese electronics industry in the early 1950s: master as quickly as possible those types of production technology that would enable it to capitalize on its low labor costs while, at the same time, reaping economies of scale. Logically, this implied a focus on rapid capacity and market share expansion primarily through exports. Given the limited size of Korea´s knowledge and capability base during this period, it was clear that the growth of the electronics industry would have to occur primarily on the basis of foreign technology. It was equally clear that, given the weakness of the private sector, the government would have to play a leading role. Our analysis covers four aspects: the catalytic role of foreign direct investment (I.2), the symbiotic relationship between the government and the chaebol (I.3), international technology sourcing (I.4), and some characteristic features of Korean entry strategies.

I.2.The catalytic role of foreign direct investment (FDI)

Initially at least, the electronics industry diverges from the common perception that FDI has played only a minor role in the development of the Korean model[14]. Korea´s electronics exports in fact only started to take off when the country became

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13 Evidence for this can be found in the response to the recent devastating price wars in the DRAM industry. While Korean DRAM producers traditionally had focused on aggressive pricing in order to gain market share, they now share a common interest with Japanese producers in supply regulation and in the re-establishment of a stable oligopoly. This however has changed again since mid-1997, as the Won depreciation has forced Korean producers to return to aggressive pricing strategies.

14 Typical examples for this perception are Haggard, 1990, Hikino and Amsden, 1992 and Amsden, 1993.

a final export platform for a handful of U.S. semiconductor firms (Ernst, 1994b, chapter III). This was made possible by the willingness of the Korean government already during the 1960s to shift to export promotion. Combined with tough labor legislation and the ruthless suppression of labor conflicts, the Electronics Industry Promotion Law of 1969, which made electronics a strategic export industry, and the opening of the Masan Free Export Zone in 1970 contributed to a positive foreign investment climate in this industry. The main attractions for foreign electronics companies were Korea's cheap female labor and the incredibly long annual work hours, together with policies favorable to the promotion of export manufacturing.

In 1972, foreign firms, of which there were eight, accounted for about a third of Korea´s electronics production and 55 % of its exports; their share in exports fell below 40% only in 1980 (Bloom, 1992, p.28). By opening up export channels for assembled chips and for simple consumer devices, FDI did indeed play an important catalytic role during the critical early phase of the development of the Korean electronics industry. FDI also exposed Korean workers and managers to some new organizational techniques, which, while not necessarily "best practice," certainly contributed to a gradual erosion of the traditional highly authoritarian Korean management practices and their inherent rigidities and inefficiencies. Cost-cutting and the need to comply to some minimum international quality standards without any doubt gave rise to some limited indirect learning effects related to the formation of basic operational capabilities for final assembly, logistics and facility management (Ernst, 1983, pp.156-166).

I.3. A symbiotic relationship between the government and the chaebol

Yet this was about all that foreign firms were willing to contribute during this early stage. For that to change, Korea needed systematic and well co-ordinated government policies to promote the development of Korean firms. Since the mid-1970s, it is the Korean government, together with the chaebol, that, in a close symbiotic relationship, became the main carriers of technological learning. This shift in the center of gravity among the social carriers responsible for the development of Korea's electronics industry was due to a number of factors. In semiconductor assembly, American firms became increasingly attracted by new low-cost locations in the Philippines and Malaysia, and gradually shifted most of

their assembly activities to these two countries. Confronted with an increasing cost of capital, most of these companies were keen to reduce their equity involvement and began to shift to much looser forms of contract assembly, subcontracting and OEM arrangements (Ernst , 1997c). Japanese firms, in turn, choose a somewhat different route, and this applies both to chip assembly and to their activities in other electronic components. In contrast to the U.S. firms' reliance on foot-loose offshore assembly, most Japanese firms concentrated on factory automation at home and gradually withdrew from offshore assembly activities both in Korea and Taiwan (Ernst, 1997 a).

Parallel to this process of gradual withdrawal of foreign firms, there have also been push factors resulting from the increasingly demanding requirements imposed by the Korean government on foreign firms to contribute to local value-added and to increase the transfer of technology. Japanese firms in particular were extremely reluctant to open up their closed international production networks and were concerned about a possible "boomerang effect" through involuntary technology leakages. At the same time, rising competition from the increasingly powerful chaebol added further pressure on foreign firms. Confronted with the alternative to either upgrade their existing investments beyond the stage of assembly and to do so in cooperation with local firms, or to shift production elsewhere within East Asia, most of the foreign firms chose the second option. As a result, Korea today has one of the lowest rates of inward investment in East Asia, despite serious attempts by various Korean governments to bring foreign investment back into the country as a vehicle for accelerated technology diffusion. Since 1988, Korea has failed to appear on the list of the preferred ten foreign investment locations for both U.S. and Japanese electronics firms[15].

Policy interventions by the Korean government have played an important role in shaping the competitive strengths and strategies of Korean electronics firms. Korea´s successful catching-up in the electronics industry has been based on a development model that combines four elements: First, its defining element is an unusually close, almost symbiotic relationship between the the "developmental state" that defines a national industrial strategy, and huge family-owned

[15] Interview with senior official of the Economic Planning Board (EPB), November 1995

conglomerates, the chaebol[16]. Second, a rich arsenal of "directed credit" instruments has been a hallmark of Korea´s industrial policy: access to subsidized credit and tax privileges has been coupled with strict performance requirements.[17] Third, Korea has frequently used selective "infant industry" protection as part of its industrialization strategy, especially in the electronics industry. But import protection was mostly coupled with offsetting incentives for export sale, with the result that overall neutrality was roughly maintained (OTA (1991, p.296)). The import protection enabled producers in a new industrial sector like electronics to exploit learning economies, while the export incentives provided the opportunity to reap scale economies not available in the domestic market. Finally, restrictions to the inflow and outflow of capital have remained in place until very recently (Kwon Okyu (1994) and Graham (1994)). This development model worked extremely well, as long as the goal was catching-up: it succeeded to channel Korea´s large household savings[18] into investment that has produced an incredibly fast expansion of industrial manufacturing capacity and international market share.

I.4. International technology sourcing

The Korean way of building technological capabilities in the electronics industry resembles the Japanese model most closely in its utilization of foreign technology. Rather than letting foreign firms establish local subsidiaries and decide on the speed and scope of technology diffusion, the government encouraged some of the leading chaebol to focus on learning and knowledge accumulation through a variety of links with foreign equipment and component suppliers, technology licensing partners, OEM clients and minority joint venture partners. By licensing well-proven foreign product designs and by importing most of the production equipment and the crucial components, Korean electronics producers were able to focus most of their attention

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16 While originally the government has been in command, its capacity to control the chaebol has been eroded since the 1980s, due to the increasing power of the latter.

17 Over time, such performance requirements however became much looser and more difficult to enforce. There are basically two reaons: the increasing international exposure of the chaebol which have enabled them to borrow on international capital markets; and poorly designed and implemented liberalization policies which have blurred existing rules and regulations.

18 Korea´s gross savings have increased from 15% of GDP in the 1960s to about 35% in the early 1990s (Aliber, (1994), p.341), way above savings ratios in industrialized countries.

on three areas:[19] i) the mastery of production capabilities, initially for assembly, but increasingly also for related support services and for large mass production lines for standard products; ii) some related minor change capabilities, ranging from "reverse engineering" techniques to "analytical design" and some "system engineering" capabilities that are required for process re-engineering and product customization; and iii) some investment capabilities, especially the capacity to carry out at short notice and at low cost investments in the capacity expansion and/or modernization of existing plants and in the establishment of new production lines.

In order to succeed, Korean electronics firms had to develop the knowledge and skills that are necessary to monitor, unpackage, absorb and upgrade foreign technology. Equally important was a capacity to mobilize the substantial funds for paying technology licensing fees and for importing "best practice" production equipment and leading-edge components[20]. Most Korean electronics producers arguably would have hesitated to pursue such high-cost, high-risk strategies had they not been induced to do so by a variety of selective policy interventions by the Korean state. Getting relative prices "wrong"(Amsden [1989]) has been important. Government policies were focused on a judicious combination of export promotion and import restrictions, sectoral targeting and the channeling of investment funds to a select group of “national champions”. By providing critical externalities such as information, training, maintenance and other support services, and finance, the Korean government has fostered the growth of firms large enough to overcome high entry barriers.

Capability formation in the Korean electronics industry historically has been characterized by a heavy reliance on international technology sourcing. This has enabled Korean electronics firms to reverse the sequence of technological capability formation (Dahlman, Ross-Larson and Westphal [1987]). Rather than proceeding from innovation to investment to production, they could take a short-cut and focus on the ability to operate production facilities according to competitive cost and

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[19] For the underlying conceptual framework of capability formation, see Ernst, Mytelka and Ganiatsos [1998]. See also the excellent analysis in Bell and Pavitt [1993].

[20] Already in the 1970s, most Korean electronics firms had to pay on average roughly 3% of their sales for technology licensing fees, a share which since then has increased to more than 12% (Lee Jin-Joo [1992], pp.132, 139).

quality standards. Production capabilities thus were used as the foundation for developing capabilities in investment and adaptive engineering, while product and market development and process innovation were postponed to a later stage of development. Through "reverse engineering" and other forms of copying and imitating foreign technology and by integrating into the increasingly complex international production networks[21] of American, Japanese and some European electronics companies, Korean electronics firms were able to avoid the huge cost burdens and risks involved in R&D and in developing international distribution and marketing channels. This was conducive for rapid catching-up. At the same time however this approach has constrained Korea´s ability to cope with the requirements of industrial upgrading.

The most prominent form of international technology sourcing are OEM (= original equipment manufacturing) arrangements. Historically, it made all sense to start with a focus on assembly based on borrowed technology and to enter international markets with the help of powerful foreign OEM clients. Take the example of consumer electronics[22]. This is an industry where economies of scale are critical[23]. Rapid expansion of market share thus is an essential prerequisite for successful late

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21 The concept of an "international production network"(IPN) is an attempt to capture the spread of broader and more systemic forms of international production that cover all stages of the value chain and that may or may not involve equity ownership. This concept allows us to analyze the globalization strategies of a particular firm with regard to the following four questions: 1) Where does a firm locate which stages of the value chain? 2)To what degree does a firm rely on outsourcing? What is the importance of inter-firm production networks relative to the firm's internal production network? 3) To what degree is the control over these transactions exercised in a centralized or in a decentralized manner? And 4) how do the different elements of these networks hang together? This concept has been developed in studies prepared for the OECD (Ernst, 1994b), the Sloan Foundation (Ernst, 1997c); and the Brookings Institution 1997 (Ernst, 1997a)

22 Learning through OEM arrangements was not confined to the consumer electronics industry. Substantial spillover effects occurred into other segments of the electronics industry and the manufacturing sector at large, as some technologies used in consumer electronics products are similar to those used in industrial and professional electronic systems. A typical example for such spillover effects are picture tubes. Throughout most of the 1980s, computer monitors used to be built around the same cathode ray tube (CRT) technology that is used in TV sets. As a result, Samsung and Goldstar could use the technological capabilities accumulated in the production of picture tubes for TV sets to establish a strong position as OEM suppliers of computer monitors.

23 For reasons of quality and reliability, production requires automatic component insertion machines. Such machines have very high throughputs and can be effectively utilized only in connection with high-volume assembly operations. Minimum efficient scale for a color TV plant for instance typically exceeds 400,00 sets per year, with minimum investment thresholds ranging between $15 million and $40 million. Minimum efficient scales are even higher for TV picture tubes, starting from a minimum capacity of 1.4 million tubes per year, with an estimated $75 million to $90 million as the investment threshold. (Ernst and O'Connor [1992], pages 183-185)

entry strategies in consumer electronics. In Korea, the domestic market was clearly insufficient to exhaust the relevant scale economies. The main focus thus had to be on exports. For a long time, directed credit and Korean consumers had to subsidize the learning costs of their consumer electronics producers, paying substantially higher prices for lower quality products.

Korean consumer electronics manufacturers have entered exports by focusing on the final assembly of mature and proven imported product designs. Attempts to upgrade the industry structure were postponed to a later stage. This specific industrialization pattern gave rise to a particular pattern of technological learning: the focus was on the development of production and, linked to that, the capacity to reproduce similar investment projects. Production capabilities were primarily developed for the different stages of final assembly, most of it related to the insertion of components onto printed circuit boards. From the mid-1980s onwards, this was complemented by the development of component manufacturing, especially for picture tubes and some semiconductors. Yet, very little progress has been achieved in product design.

Rapid expansion of capacity and international market share would have been impossible, if Korean firms would have tried to start off with a more integrated production system. And OEM arrangements have proven to be one of the most cost-effective methods for acquiring core capabilities in production and investment. OEM arrangements provide the supplier with a high volume of business, which permits the realization of scale economies. The often tedious and grueling qualification process that any potential supplier has to pass before he can aspire to get a contract opens up a variety of learning possibilities about its organizational deficiencies and technological weaknesses. In addition, the customer often provides technical assistance in engineering and manufacturing processes in order to ensure quality and cost efficiency. This applies in particular to capabilities in tooling (e.g., plastic molds), the lay-out, use and adaptation of automated insertion, soldering and assembly equipment, and specialized equipment for coil winding and other operations required for various subassemblies, for instance, of a TV set. At the very least, the customer must supply detailed technical “blueprints” to allow the supplier to produce according to specifications. The most important immediate advantage is

that the customer takes responsibility for marketing and distribution, saving the OEM supplier substantial investments in those areas.

OEM arrangements, however, can also have substantial drawbacks[24]. A firm may become "locked into" an OEM relationship to the extent that it is hindered from developing its own independent brand name recognition and marketing channels. Profit margins are substantially lower in OEM sales than in own brand name sales, which in turn makes it difficult for the Korean companies to muster the capital needed to invest in R&D that eventually might lead to the introduction of new products. This constraint, however, is of limited importance, as long as sales volumes through OEM contracts are large and fairly well predictable so that, despite low profit margins, total earnings may be substantial.

OEM exports continue to account for a substantial share of Korea's consumer electronics exports. In 1988, around 50% to 60% of all Korean exports of color TV sets and VCRs were carrying OEM brands (Jun and Kim [1990], p.22). And four years later, in 1992, the OEM share of consumer electronics exports was reported to have increased to nearly 69%.[25] Over the last few years, Korean companies have moved out of low-end OEM arrangements (e.g., for standard, small-sized TV sets) and strengthened their position for products that require more demanding production capabilities (e.g., VCRs and computer monitors). In earlier OEM arrangements the Korean company was basically restricted to printed circuit board (PCB) assembly and had to purchase most components from the foreign client. More recently, however, Korean companies have qualified for more demanding OEM arrangements in which they supply not only the components but are also responsible for detailed design or for design modification.[26]

During the late 1980s, everyone in Korea began to talk about the necessity to move beyond the OEM trap and expectations were running high that, given the substantial amount of accumulated technological and organizational capabilities, this could be done without much pain. All of the three major consumer electronics manufacturers

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[24] An early analysis of such drawbacks can be found in Ernst and O`Connor (1989). For an empirical analysis of the response of Acer and other Taiwanese computer companies to such drawbacks, see Ernst (1998b).

[25] Interview at the Korean Institute of Economics and Technology (KIET), November 1993

[26] For an analysis of the increasing variety of OEM arrangements and the impact on technology diffusion, see **Ernst (1997c)**

of Korea have since then tried to increase their brand name recognition abroad and have made huge investments to build up an overseas marketing, distribution and service network. In some cases, such attempts have worked quite well, as for Samsung's TV sets and VCRs for the low-end market segments in the United States, and for Daewooís microwave ovens in France. In most cases, however, the transition to original brand name (OBN) strategies has been rough and full of pitfalls. After years of heavy advertising and PR promotion, Korean electronics firms must still contend with an image that their products are of inferior quality and reliability.

Product development is still primarily conceived as a gradual improvement of a given Japanese product design. Due to their heavy reliance on OEM manufacturing, Korean companies are very much followers of the latest product designs developed elsewhere, mostly in Japan. In the words of a manager of the LG group: "We are used to take Sony, Hitachi and Matsushita as our natural benchmarks without ever asking whether we could do it better."[27] Korean firms have a weak capacity to develop new designs and to collect early on the relevant information on new market trends and customer preferences.[28] This applies to TV sets, VCRs and audio equipment as well as to household appliances, in which Korean companies continue to depend to a considerable degree on OEM arrangements to keep up with the fast changing international markets.

Strategic marketing continues to play a marginal role in the Korean innovation process. The goals of innovation are set by the established foreign benchmark firms. Almost no attempt has been made until very recently to identify still undiscovered customer needs and to use this knowledge to develop new markets. It should be mentioned however that, over the last few years, all three chaebol active in consumer electronics have identified this passive acceptance of foreign product designs as a major barrier to sustained competitiveness. All three are now considering or have started to implement important organizational reforms that should enable them to link together more closely strategic marketing and innovation

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[27] Interview at the LG group, November 1993

[28] This contrasts sharply with Taiwan's PC industry, in which early access to market intelligence enables firms to accelerate speed-to-market and to continuously upgrade their products. For evidence, see San Gee and Wen-Jeng Kuo [1998] and Ernst, 1998b.

management. All three also claimed that they have now inter-disciplinary product teams working on original product designs. The fact that top management is now more willing to spend substantial resources on original brand design may help to break the old passive design mentality. Such a change is overdue. Product life cycles have been drastically shortened both for consumer electronics and for PC-related products. Competitive success thus increasingly depends on whether a firm is able to rapidly adapt its product designs to the changing requirements of the main international export markets.

I.5. Entry strategies: the example of semiconductors

The pace and scale of the capacity and market share expansion of Korea´s semiconductor industry is unprecedented in the history of the electronics industry. Never before has a country been able to move so rapidly from the position of an insignificant outsider to that of the market leader in a highly capital-intensive industry saddled with incredibly high risks and entry barriers[29]. How was it possible that Samsung, together with LG and Hyundai, were able to enter the DRAM market at record speed and to erode the once seemingly watertight grip that a tight Japanese oligopoly had come to impose on this industry since the mid-1980s?

Two external factors need to be mentioned upfront, before we can discuss how the Korean way of building technological capabilities may have contributed to this success. The first is a probably unintended, yet very consequential side effect of the September 1986 U.S.-Japanese agreement on trade in semiconductors: due to the unrealistically high price floors set for DRAM imports into the United States, Korean producers were able to outprice their Japanese rivals at price levels that, in 1989, began to generate substantial profits (Ernst, (1987)). A second external factor has been the strategic decision of U.S. semiconductor producers and computer companies to create an alternative, low-cost source for DRAMs in order to tamper oligopolistic pricing and supply behavior of the Japanese majors (Ernst and

[29] In Ernst (1994b, I have analyzed the development of Korea´s semiconductor industry (chapter II) and documented how the leading Korean semiconductor producer Samsung Electronics was able to enter the manufacturing of computer memories, despite the existence of substantial entry barriers (chapter IV).

O'Connor [1992]). It is plausible to assume that, without these two external factors, Korea may have had a much harder time entering the DRAM market segment.

As for the Korean contribution, the first factor to mention is the willingness and the capacity to spend huge amounts of money on investment and technology acquisition.[30] Between 1983 and 1989, the three chaebol are reported to have invested more than $4 billion on production equipment. This amount can be considered to be the original entry fee. But while catching-up is already quite costly, keeping-up and getting ahead leads to an even higher fixed capital cost burden. Since 1987, annual capital spending has increased from $800 million to an estimated $1.8 billion in 1993, which in that year equalled more than 20% of the world's total semiconductor facility investment[31].

In order to get an impression of the tremendous overall cost involved in Korea's entry into semiconductors, let us first compare, for the five years between 1988 and 1992, cumulative capital spending with cumulative sales. We find that on an average Korean semiconductor chaebol had to spend nearly 51% of their semiconductor sales on capital investment, $5.7 billion out of a sales total of $10.2 billion[32] . As if this would not already be enough, we need to add the quite substantial licensing fees that Korean semiconductor producers have to pay for U.S. and Japanese technology. It is estimated that in 1992 and 1993 the Korean semiconductor industry had to spend 14% and 16% of its annual turnover on royalty payments, i.e. $281 million and $322 million respectively. 85% of these payments were reported to go to the U.S. semiconductor industry, which provides an interesting and somewhat surprising contrast to Korea`s otherwise high dependence on Japanese technology, especially for consumer electronics.

A second important prerequisite of Korea's successful entry into semiconductors relates to the specific nature of the technology acquisition strategies pursued. These

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[30] If not indicated otherwise, the following figures are provided by the Korea Semiconductor Industry Association (KSIA).

[31] In the same year, Samsung alone had the third largest capital expenditures of production equipment ($930 million), after Intel ($2.1 billion) and Motorola ($973 million), but well ahead of Toshiba ($519 million), NEC ($482 million) and Hitachi ($409 million). Even Goldstar's and Hyundai's capital expenditures, $417 million and $401 million, came close to or even surpassed that of their Japanese rivals. (VLSI Research figures, quoted in Electronics New, 12/6/93, p.4)

[32] Sales figures provided by Dataquest, September 1993

strategies were based on a judicious combination of three main elements which enabled the chaebol to participate in international technology networks and to maximize their internal learning possibilities. First, all of them established early on subsidiaries in Silicon Valley that served as listening posts for intelligence gathering on technology and market trends. These subsidiaries were also used for R&D activities that complemented and helped to direct or correct similar efforts at home. A second element of technology acquisition has been a pervasive reliance on "second-sourcing" agreements in which the chaebol were licensed by leading U.S. and Japanese semiconductor producers to manufacture some of their DRAM designs [33]. The chaebol also used a third approach to technology acquisition through contract manufacturing, the so-called silicon foundry services provided for leading American ASIC (application specific integrated circuit) companies like LSI Logic and VLSI Technology. Based on the gate array or standard cell designs received from these foreign companies, the chaebol used their strength in process technology and their capacity to rapidly improve yields to produce such devices at short notice. Being forced to comply to the stringent design rules typical for ASIC devices, the chaebol thus were able to deepen their knowledge about necessary process improvements.

More recently, there has been a tendency to combine these different individual approaches into somewhat broader package deals aimed at cross-technology-sharing. As the chaebol expanded their share in international DRAM markets, they were able to strengthen their bargaining position with regard to licensing agreements, as a result of which we now witness an increasing trend towards cross-licensing and mutual patent swaps, which today link all of the chaebol with the leading Japanese semiconductor producers. More and more, the chaebol get involved in international technology sourcing networks, which include links with other firms (inter-firm networks) and attempts to tap into and use key elements of the national innovation systems of other countries (inter-organizational networks). These networks now typically cover a great variety of arrangements, ranging from

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[33] Examples of such second-sourcing include the following link-ups: Goldstar with AT&T (for 256K DRAMs) and Hitachi (for 1Mbit and 4Mbit DRAMs); Hyundai with Texas Instruments (for 256K and 1Mbit DRAMs); and Samsung with Micron Technology (256K DRAMs), and Intel (microcontrollers, microprocessors, DRAMs and EPROMs -- erasable programmable read-only memories). Some of these arrangements are analyzed in detail in Ernst 1994a.

second-sourcing and fabrication agreements to technology licensing and cross licensing, patent swapping, joint product or technology development, the exchange of researchers and guest engineers, and standard coalitions (e.g., for RISC (reduced instruction set computing) and flash memories). Within a few years, technology acquisition approaches pursued by Korean semiconductor producers thus have experienced major changes, moving from the "reverse engineering" of licensed chip designs to much broader and increasingly systemic forms of international technology sourcing.

II. Truncated Industrial Upgrading: What are the Limits to the Korean Model?

II.1. A simplified model

Much of the literature on Korea remains married to a perspective of comparative statics: the main concern is to distill key features of the Korean model and to set this model apart from the experience in other countries[34]. The underlying concern is to demonstrate how this medium-sized country at the periphy of the world economy was able to develop in the face of adversity and dependence. Such an approach certainly has played an important role in correcting some fundamental misconceptions in development economics, with regard to the role of the state and the role of firms as the central carriers of industrial upgrading. There is now a wide consensus that "…markets and governments are complementary. The state is essential for putting in place the appropriate institutional foundations for markets." (Joseph Stiglitz, chief economist of the World Bank, quoted in the Financial Times, June 26, 1997)

Yet, this approach is no longer sufficient today. In order to understand what went wrong with the Korean model, it is necessary to focus on the dynamics of change[35]. In order to understand how learning and capability formation have shaped over time Korea's economic development, one must address questions like: What are the

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[34] Typical examples are Amsden 1989, and Wade 1990.

[35] This is in line with evolutionary economics, andits applications to economic development and the growth of the firm. (Freeman, 1982; Nelson and Winer, 1982; Dosi et al, 1988; Lundvall, 1992; Nelson, 1992; Bell and Pavitt, 1993; Nelson and Pack, 1995; Gu Shulin, 1996; Lall, 1997; and Ernst and Lundvall, 1997)

limits to the Korean model? What changes did occur in response to these limitations in the institutional set-up and policies that constitute Korea's innovation system? And how have these changes affected Korea's capacity for industrial upgrading?

It is now time to identify some important weaknesses of the Korean model. I argue that the very same model of development that has been conducive for rapid catching-up has acted as a major barrier for a further upgrading of the electronics industry. In order to explain this puzzle, I will use the following simplified model of truncated industrial upgrading. I assume that firm strategies are conditioned by government policies and industry structure. These two factors also interact: government policies are shaped by the existing industry structure; in turn, they also determine its evolution. Industrial upgrading and firm growth condition the need for, and the ability of, governments to intervene[36].

A distinguishing feature of the Korean model has been a symbiotic relationship between governments and large business groups (the chaebol). This has given rise to the following *vicious circle of truncated industrial upgrading: i) a heavy reliance on credit and ii) an extremely unbalanced industry structure have led to iii) a narrow knowledge base, and iv) a sticky pattern of specialization.* The development of Korea´s electronics industry fits the pattern of large-scale, capital-intensive latecomer industrialization described by Gerschenkron (1962): easy access to large amounts of patient debt capital has been a critical source of competitive strength for the Korean chaebol. This has shaped key features of corporate strategy in terms of product specialization, type of production, size of commitment and entry strategy, vertical integration, competition focus and technology management. Korea's successful entry into the electronics industry has been a forced march to develop a mass production capacity that can serve high-growth export markets for homogeneous products; very little upgrading has occurred into higher-end and rapidly growing market segments for differentiated products and services. Once a decision has been made to enter a sector, the chaebol normally move in on a massive scale and in a highly integrated manner. By channeling funds at concessionary terms to a handful of *chaebol*, the state has created powerful domestic oligopolies. Korea´s

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[36] On the dynamics of industrial policies, industry structure and firm strategies, see Evans (1995) and Chang Ha-Joon (1997).

extremely unbalanced industry structure has given rise to a peculiar form of competition strategy: firm growth has occurred through *octopus-like diversification* into many different and unrelated industries rather than through an accumulation of knowledge through industrial upgrading. The result has been a narrow domestic knowledge base, which in turn has made it difficult to move up the ladder of specialization.

This development model has worked well, as long as major export markets kept growing rapidly. As we will see in the next sections, this is no longer the case today. The result is over-capacity and price wars, as well as to a dramatic increase in the country's exposure to debt. After three decades of rapid growth, Korea is now facing a major crisis. External factors, caused by the volatility of international financial markets, have acted as a catalyst; yet the root causes for this crisis are primarily home-made. A failure to upgrade is one important reason for Korea´s vulnerability to the current crisis in the financial and currency markets: it has reduced the capacity of Korean firms to generate a sufficiently large amount of foreign exchange that is necessary to service their huge debt.

In what follows, I first review evidence on two indicators of truncated industrial upgrading: a sticky specialization pattern (II.2.), and a narrow domestic knowledge base (II.3.). I then discuss the role of two explanatory factors: Korea´s high-debt growth model (II.4.) and its unbalanced industry structure (II.5.)

II.2. Sticky specialization

Specialization is an important indicator of the degree of industrial upgrading that a country has achieved. Industrial economists distinguish specialization patterns that reflect differences in the product mix (homogeneous versus differentiated products[37]), and in the types of production process (mass production versus flexible

[37] Homogeneous (standard) products are distinguished from differentiated (unique) products, in terms of the complexity of their technology and the demand patterns they are facing. Homogeneous products are based on widely accessible and mature technology and are thus easy to replicate. Changes in demand patterns are fairly predictable and interactions with customers plays a role only at the margin. Differentiated products, on the other hand, are based on new technology whose design features are still fluid and are thus difficult to replicate. This is due to the high entry barriers that result from the high R&D outlays required. Close interaction with customers is a critical prerequisite for success. It is argued that different market structures will result from these different product features: for differentiated products, firms can charge premium prices, while for homogeneous products, price competition is the over-riding concern. See, for instance, Baumol, Panzer and Willig (1982) and Nilsson (1996).

production). Various attempts have also been made to develop generic sectoral specialization categories that combine key aspects of this simple matrix [38].

Let us now look at the product mix that is typical for Korea´s electronics industry[39]. A fundamental problem is a *sticky pattern of specialization*: the focus has been on capacity and international market share expansion for homogeneous, mass-produced products; with few exceptions, Korea has failed to upgrade into higher-end and rapidly growing market segments for differentiated products that require flexible production. Almost without exception, the chaebol have targeted those segments of the electronics industry that require huge investment outlays and sophisticated mass production techniques for fairly homogeneous products like microwave ovens, TV sets, VCRs, computer monitors, picture tubes and computer memories, especially DRAMs. Korean electronics firms typically have focused on the mass production of capital-intensive homogeneous products that are characterized by huge investment thresholds and proven technologies. Overwhelmingly, the focus has been on consumer electronics and components, with only limited inroads into industrial electronics. This is in line with our argument that sticky specialization is a major characteristic of the Korean model. In the more design-intensive sectors of the computer industry, Korean chaebol however lag well behind Taiwanese firms. Burdened with unimpressive “me too” products, they have all failed to establish themselves as credible competitors.

Sticky specialization in semiconductors

A particularly disturbing feature of Korea´s specialization pattern is that it typically combines high investment thresholds and highly volatile income streams: in their choice of sectors, the chaebol are willing to take considerable risk that result from highly volatile markets. Typical examples are DRAMs and advanced displays that are prone to periodic boom-and-bust cycles and hence do not generate a steady flow

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38 Examples include: Pavitt, 1984; Guerrieri, 1991; OECD , 1992b; Ernst. and Guerrieri 1997; and Nilsson, 1996

39 For detailed evidence, se Ernst 1994b, chapter II.

of profits. For companies with a high debt-equity ratio, this is obviously not an optimal choice[40].

Take the case of DRAMs[41]. Let me first clarify the nature of the technological capabilities required for the production of these devices. Five of them can be discerned: wafer production, circuit design, wafer fabrication, assembly and packaging, and testing. In a nutshell: Korea has excellent assembly capabilities over a broad range of products. Its wafer fabrication capabilities are excellent or good for a limited number of products, i.e., DRAMs, SRAMs and ROMs. Other than that, very little has been achieved, and there continue to be glaring deficits in particular for circuit design.

Of much greater importance however is that Korea's semiconductor industry is based on an extremely weak foundation, in terms of the materials and production equipment required. In the early 1990s, 90% of the production equipment had to be imported, with 50% originating from Japan. It will be extremely difficult to reduce this dependence. Only joint production with leading overseas manufacturers is likely to help. There is some evidence now that this pragmatic strategy may work. One reason is that the cash-stripped chaebol are eager to establish joint ventures with American and Japanese electronics firms. Already before the crisis, leading U.S. producers like Applied Materials, Lam Research and Varian Associates have concluded such joint ventures, as Korea had become a major market for semiconductor production equipment[42]

Levels of import dependence are also quite high for semiconductor materials, particularly for high value special materials. Korea's current annual consumption of semiconductors materials is approximately $600 million, with 70% of total consumption being imported (40% from Japan and 20% from the United States). Some progress has been made in the domestic production of silicon wafers, using foreign technology obtained either through licensing or joint ventures. Most

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40 For a theoretical discussion of some trade-offs involved in the choice of specialization, see Dalum, Bent et al, 1998, “Is there such a thing as a good specialization pattern?..”

41 The following information is based on author´s interviews in the Korean electronics industry, March 1996

42 However, Japanese equipment manufacturers, especially Canon and Nikon, have been reluctant to establish similar joint ventures with Korean partners.

domestic production, however, is still restricted to relatively simple materials like lead frame, bonding wire and packaging materials for chip assembly.

Probably the most important weakness relates to circuit design and the limited capacity of Korean firms to broaden their product portfolio and to develop new products and markets. Beyond DRAMs and some other memories like Static Random Access Memories (SRAM) and Erasable Programmable Read-only Memories (EPROM), Korean firms have played no role at all in international semiconductor markets. In other words, Korean firms are only able to compete in a particular segment of the world market, DRAMs, that currently generate roughly 24 % of worldwide semiconductor revenues (Dataquest, 1996). Korea's competitive position in semiconductors thus remains highly fragile. The three leading Korean semiconductor producers in fact are all heavily dependent on computer memories: 80% of Samsung's semiconductor revenues come from memories, and in the case of Goldstar and Hyundai, this share is even higher, i.e., 87% and 90%[43]It is this heavy dependence on memories, and especially on DRAMs, which clearly distinguishes the Korean semiconductor industry from its international competitors and keeps them in a highly vulnerable position. This vulnerability results from the fact that demand for DRAMs is highly volatile, while investment thresholds continue to grow rapidly. In the case of the largest Japanese semiconductor producer, NEC, for example, only 35% of its semiconductor revenues were generated by MOS (metal oxide on silicon) memories.

The key issue today for the Korean semiconductor industry is whether or not it will succeed in broadening its product portfolio and move beyond computer memories. As technology management is still overwhelmingly dominated by a production bias, I am somewhat skeptical to what degree and how fast design and product development capabilities can be developed. If such changes in the product mix do not come soon, this may have quite negative consequences. The absence of Korea from most international semiconductor markets has led to a very unbalanced international trade structure, which may not be sustainable for long: Korea continuously has a huge trade surplus for memory chips, while at the same time

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[43] Figures are courtesy of the Korean Semiconductor Industry Association (KSIA).

accumulating equally huge deficits for microprocessors, ASICs and video image chips.

The narrow focus on memory products also has very negative implications for the overall structure of the electronics industry at large. Korea keeps exporting more than 90% of its total semiconductor output, while at the same time importing more than 87% of its domestic demand. Such an extreme imbalance between supply and demand makes it very difficult to broaden and deepen forward and backward linkages within the electronics industry and to place it onto a more viable basis. It is probably fair to say that Korea's semiconductor industry represents today a modern version of the classical mono-product export enclave, characterized by a minimum of linkages with the domestic economy. There is, however, one important difference: as shown before, the cost for entering the semiconductor industry is horrendously high, and certainly exceeds that of entering the plantation industry.

It is necessary to place Korea's entry strategy into the semiconductor industry into the proper context. While catching-up in this industry has been a major achievement, it should not be interpreted to imply that Samsung, Goldstar and Hyundai have been able to move beyond their strength in mass production and that they have now established a firm foothold in highly R&D-intensive forms of industrial production. The very high entry barriers typical for DRAMs are due less to their R&D intensity than to their capital-intensity, very high economies of scale and the extremely volatile nature of demand for these devices. The minimum efficient scale for producing these devices is now more than $1 billion of annual sales. This implies that only firms that have reached the critical threshold of 5% of world production can compete successfully.[44] Competition in DRAMs centers on the capacity to invest in huge mega-plants churning out a limited variety of standard products and on the capacity to improve as quickly as possible yields and productivity. Wafer fabrication lines thus are typical examples of mass production.

In contrast to microprocessors, logic and analogue devices, DRAM designs are not complex at all. The main focus is on improving process technology and thus learning economies and yields, primarily through continuous improvements on the

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[44] For a detailed analysis of entry barriers in different sectors of the electronics industry, see Ernst and O'Connor [1992].

shopfloor and tedious trial-and-error. DRAM designs need to be simple, repetitive and safe enough, so that the risks and complications entailed in producing these devices with complex process technologies are minimized. The device should be easily testable in order to isolate defects. With progressive miniaturization, this last requirement becomes even more important -- the circuits become so tiny that if defects cannot be located by electrical testing, finding them becomes prohibitively expensive. To compete in the DRAM market, a firm must be able to mobilize huge investment funds, implement complex investment projects quickly and at low cost, and have sufficient financial clout to discount the periodic huge losses that result from extremely volatile demand and the periodic emergence of huge surplus capacities. Once these fundamentals are in place, a firm needs to organize its production in such a way that it can rapidly improve yields and be the first to the market as the lowest--cost supplier.

Until the outbreak of the financial crisis, the chaebol were well placed to cope with such entry requirements. They had guaranteed access to "patient capital" and ample opportunities for internal "cross-subsidization" and thus were among the few firms world-wide that could cope with the demanding financial requirements of the DRAM business. The chaebol also have been able to accumulate increasingly sophisticated production and investment capabilities, both in typical mass production industries like cars and consumer durables and in resource-intensive process industries like the steel industry. After the financial crisis hit, this is no longer the case.

It is probably fair to say that Korea's entry strategy into semiconductors did not fundamentally differ from its earlier entry into shipbuilding, the steel industry, or the production of picture tubes for TV sets and monitors. What DRAMs share with these other industries is that success does not require a strength in research and technology development, at least not during the initial entry phase. Rather, the success of the chaebol has been primarily a result of their capacity to raise incredibly large funds for high-risk investments into huge mass-production lines for standard products. High risks in this case do not result from technological uncertainty but from the extremely volatile nature of demand and from the periodic

emergence of huge surplus capacities.[45] In other words, competition in DRAMs is of a fairly conventional nature, with size, economies of scale and first mover advantages being of primary importance. Korea's success in this particular segment of the semiconductor industry should thus not be construed to indicate that Korea is now able to compete in the so-called "new industrial paradigm" industries. This, on the other hand, should not belittle our appreciation of the impressive achievements that Korean companies have made in the mass production of computer memories.

Impact of sticky specialization

It is due to his sticky pattern of specialization that I think we have to be careful with statements which claim that Korean firms "make products that sell in the most demanding markets - if the exchange rate is right." (Veneroso and Wade (1998, p.1) As Korea has failed to upgrade its industry structure and product mix, such a statement may in fact be no longer true today. Since the early 1990s, there has been a disturbing change in the destination of Korea´s exports away from the demanding American and European markets towards an increasing reliance on emerging markets. Take for instance the share of Korean exports that today goes to ASEAN countries, China and Taiwan: from almost zero only a few years ago, it has increased to almost 30%[46]. Korea , meanwhile, is losing market share in the U.S. and Europe.

A high dependence on emerging markets has three substantial disadvantages: i) there is a decline in competitive pressures to upgrade product performance and quality; ii) there is less exposure to sophisticated customers; and iii) it gives rise to an extreme vulnerability to exchange rate fluctuations. Probably the most serious consequence of sticky specialization is that it will constrain international market share expansion. Take again the case of the electronics industry: There are now clear limitations to a further rapid growth of exports to Korea´s major markets in OECD countries. The first warning signs came in 1992 when electronics exports to the U.S.

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[45] For an early model of the volatility of demand and recurrent periodic surplus capacties in semiconductors, see Ernst [1983], chapter I.

[46] According to a financial analyst, "Korea is highly exposed to emerging markets and that is not the place you want to be dependent on for export growth right now." (Heny Morris, a director at Coryo Securities in Seoul, quoted in the Financial Times, October 29, 1997, p.5)

and Japan experienced a decline of 2.5% and 6.1% respectively, causing an overall decline of Korean electronics exports in this year (Ernst, 1994b, p.109). While exports grew again till the first half of 1996, an increasing share of these exports now consists of price-sensitive lower-end consumer devices and components for the less demanding emerging markets. By mid-1996, this surge in exports has fizzled out: most recent figures show a decline of more than 2% in the value of Korea´s electronics exports during the first half of 1997[47].

II.3. A narrow domestic knowledge base

A narrow domestic knowledge base is another indicator of Korea´s truncated industrial upgrading. Catching-up required a limited set of capabilities: a capacity to absorb and upgrade imported foreign technology and to develop operational capabilities in production, investment and minor adaptations[48]. This is no longer sufficient today. In 1995, an OECD review of Korea´s NSI concluded: "The country can no longer afford simply to import technology - which foreigners are in fact more and more reticent to introduce on concessional terms - and will have to raise the value-added and technological intensity of what it produces." (OECD, 1995b, p.5) Today, there is an even more powerful reason for such a shift in Korea´s development paradigm: the country simply does not have the foreign exchange required to buy in foreign technology[49].

Korea thus needs to create a broad-based and diversified knowledge base, especially with regard to product design, market development, the production of key components and the provision of high-end knowledge intensive support services. Such a shift in Korea's development paradigm is overdue and needs to occur rapidly: "Today, time is running out, as Korea's success in mastering world-level technology has made foreign firms increasingly reluctant to license their technology to Korea without receiving technology of equivalent value in return. As a result, although the

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47 "South Korea´s Electronics Industry: Trends in 1997/1H and Prospects for 1997/2H", Asia IT Report , October 1997, pages 21 following.

48 According to the Korea Industrial Technology Association, the umbrella grouping of corporate R&D institutes, Korea´s industrialization was achieved on the back of some 10,000 technologies imported at a cost of more than $ 13 billion since 1962.

49 According to the Ministry of Trade, Industry and Energy (MOTIE), Korean firms´royalty payments more than doubled between 1990 and 1996, from $ 1.1 billion to $ 2.3 billion.

Korean ...(NSI) ... has made extraordinary progress in a very short time, Korea's continued rapid economic growth requires even more rapid development of its capacity to use domestic sources of research and talent to innovate." (OECD, 1995 b, pages 13 and 14). So far however, Korea´s knowledge base is constrained by three main weaknesses: an insufficient critical mass of R&D; gross inefficiencies of corporate technology management; and equally important inefficiencies of its public innovation system.

i) An insufficient critical mass

Until around the mid-1980s, Korean electronics firms had little motivation to invest in R&D, for the following reasons: First, rapid capacity and market share expansion was much easier, if production was based on imported machines and technology. Second, price competition depended primarily on a combination of low labor costs and selective government support and protection: competing for government resources and contracts has been the essence of competition. Third, continuously high rates of inflation and high interests have acted as powerful disincentives to R&D expenditures: they have driven investment into real estate speculation rather than into high-risk R&D. Fourth, industrial promotion policies were biased towards quantitative goals and neglected industrial upgrading: firms received support "… on the basis of their export volumes … irrespective of their achievements in capital and labor productivities, value-added, and technologies (Sun G. Kim (1995), p.103)

Over the 1980s Korea's comparative labor cost advantages eroded, product life cycles shortened and competition intensified in the electronics industry. In response to these changes, the Korean electronics industry slowly began to develop its own R&D capacity. Between 1980 and 1984 the number of industry-managed R&D institutes increased from 8 to 32. In addition 3 government research institutes and 11 co-operatives run by small- and medium-sized enterprises were operating by mid-decade. The increased attention to R&D was also reflected in the growth of company spending on R&D, which reached over 3% of turnover in 1985. This was stimulated by tax concessions.

The real growth in R&D activity, however, only dates to the late 1980s. In 1985, for example, there were 5,249 persons engaged in R&D in the electronics industry, and

this accounted for 32% of the researchers in all Korean industry[50]. By 1990 this number had risen to 12,865 and accounted for 37% of total R&D personnel in Korean industry. A year later there were 15,923 people engaged in R&D in the electronics industry, 41% of total R&D personnel in industry. Korean researchers also began to apply for and to register patents. The number of patent applications rose from 2,552 per year in 1983-85 to 6,322 per year in 1986-88 and reached 11,320 per year in 1989-91. Of this number a total number of 11,912 patents were registered over the period 1983-91. Yet, compared to their international competitors, the overall number of patents accumulated by Korean firms has remained fairly insignificant, and indicates that there is still a long way to go.

While Korea´s R&D expenditures rose faster than its GDP, increasing its share in GDP from 1.8% in 1985 to 2.4% in 1994 (OECD (1995a), fig.1, p.47), this still leaves Korea way behind the main OECD economies. Already in 1986, the R&D/GNP ratio for Japan was 2.8%, while both the United States and the then Federal Republic of Germany reached 2.7% (Mowery [1993], table 1). In order to reach a "critical mass" for industrial upgrading, R&D investments in Korea still have to grow much further. The most vivid illustration is that, in comparison to GM's R&D budget, Korea's total R&D expenditures amount to only 54% (Kim Linsu (1997)).

Important changes have also occurred in the funding of Korea's R&D investments: the share of public sector R&D investment in the nation's total R&D expenditure experienced a dramatic fall, from 68% in 1978 to 17% in 1993 (OECD (1995a), table 2, p. 107). Today, roughly 80% of R&D expenditures are carried out by private firms; private firms also recruit nearly 60% of Korea´s R&D personnel. That implies that in terms of sheer numbers, the private sector today has become the main driving force behind the country's R&D investments. In constant prices, R&D spending in the manufacturing sector has more than quadrupled between 1976 and 1990. What is particularly noteworthy is that firms have expanded their R&D expenditures substantially faster than their sales: R&D spending as a ratio of total sales increased from 0.36% in 1976 to 1.96% in 1990. While this is an impressive achievement, it is still less than half of the current R&D/sales ratios of U.S. and Japanese

[50] These and the following figures are courtesy of the Electronics Industry Association of

manufacturing companies. In other words, for private sector R&D investments, the same caveat applies as for Korea's overall R&D investment: it is still substantially below the critical threshold level required for moving beyond the technology catching-up stage.

ii) Inefficiencies of corporate technology management

What really matters however is the quality of the R&D output, i.e. the efficiency of technology management. Patent figures indicate that Korea has a problem: while it spends more than twice the amount for R&D compared to Taiwan, the number of patents granted to Koreans by the U.S. in 1992 was only 538 compared to 1252 patents to Taiwanese (Kim Linsu (1997b) , p.15)). Korea's innovation system continues to be dominated by a handful of chaebol: they can recruit the best scientists, engineers and managers, and their strategies determine the country's research agenda[51]. Serious problems have been detected with regard to the effectiveness of the chaebol's innovation management [52]. While external technology sourcing strategies are highly sophisticated, the organization of innovation within these firms remains rather ineffectual and there is a huge potential for reorganization and productivity improvement. Organizational conservatism continues to prevail. If changes occur, they follow an outdated centralized R&D model. In contrast to the progressive decentralization of R&D which is typical today for Japanese, U.S. and European firms and which has led to an increasing outsourcing of technological development, "... the Korean manufacturing industry is still at the stage of establishing centralized R&D laboratories with the objective of concentrating scarce resources in R&D" (Kim Il Yong and Chung SunYang [1991], p.6).

This is true in particular for the leading electronics companies. As they face growing restrictions in the international technology markets, these firms have

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Korea (EIAK).

[51] For evidence, see II.5.

[52] See in particular Kim Sun G. (ed.) [1995]; Kim Hwan Suk [1991] and [1993]; Kim Il Yong and Chung Sun Yang [1991]; Kim Il Yong and Kim Chi Yong [1991]; Kim Linsu [1992] and [1993]; and Kim S. Ran, 1996. While Bloom[1992] shares much of the diagnosis with the afore-mentioned authors, he proposes a quite different therapy. For him, strengthening the chaebol would be the safest way to upgrade technological capabilities to the new competitive requirements.

shifted to quite extreme forms of centralized in-house technology generation. Successful innovation however requires continual and numerous interactions and feedbacks among a great variety of economic actors and across all stages of the value chain (OECD[1992], chapters 1-3). Organizing R&D in a centralized manner is bound to produce rigid procedures concerning information management and decision-making, with the result that product design cycles and speed-to-market become much too long. In addition, centralized R&D organizations are ill-equipped to coordinate the complex requirements of innovation. Feedback loops across the value chain thus remain weak and unreliable, and design, marketing and manufacturing often proceed in an asynchronous way.

One important difference between Korea and Japan is that in Korea hierarchical patterns of firm organization are still much more prevalent (Janelli and Yim Dawnhee, (1993)). This has important negative implications for the organization of R&D: Korean engineers and technicians are more inclined to work on their own and are much less willing to contribute to a team than their Japanese counterparts. While companies like Samsung and LG may have succeeded to overcome some of this resistance to teamwork, this is the exception rather than the rule. Korean engineers are also much less willing to dirty their hands and to get involved in tedious trial-and-error work required to solve a variety of shop-floor problems. A survey of managers of Japanese affiliates in Korea concluded that, "… individually, many of their local employees are hard-working but as a group they do not cooperate well, stick to their own territory and are not concerned about the territory of others." (Oki(1993), p.47). The same survey also stressed the "absence of information exchanges and extensive cooperation" that is typical for Japanese firms.

A bias in Korea for centralized R&D organizations also has quite negative implications beyond the boundaries of the firm. It is probably one of the main reasons for the still very weak status of domestic linkages among the different actors involved in the process of technology generation and diffusion. This applies in particular to linkages between the large electronics manufacturing companies and their suppliers of parts and components[53]. Most of these links are either with

[53] There is now a rich body of theoretical and empirical literature that shows that both end product manufacturers and component suppliers can reap substantial benefits from vertical production networks . Such networks make possible a shift to a new division of labor in R&D: they enable

foreign companies or are internalized by the leading chaebol (Bloom [1992]). Both links have considerable disadvantages. Reliance on imported components not only contributes to a continuous foreign exchange drain, but also has reduced substantially the local value-added and the learning possibilities involved in the design and manufacturing of the relevant components. In the second case, excessive vertical integration leads to very high fixed capital cost burdens and limited flexibility. As long as components are only for in-house consumption, chances are low that they will correspond to "world class" standards.

iii) Inefficiencies of Korea´s public innovation system[54]

Important inefficiencies also exist in Korea´s public innovation system. While the government´s share of R&D has declined to less than 20%, it is still large enough to play an important role. Yet, there is a serious lack of coordination among R&D programs of different ministries which has wasted Korea´s scarce resources. The current mechanism for priority-setting is highly imperfect: each ministry sets up its own program and basically feels free to pursue its own goals without much consideration for any necessary coordination among these different programs[55]. Traditionally, powerful informal social networks among key bureaucrats, politicians and chaebol managers have been able to remedy some of these weaknesses. However, as the country has moved toward more democratic institutions with the result of more stringent transparency requirements, such informal coordination mechanisms have been eroded. The current distribution of government R&D represents more the power of different ministries than the needs of the Korean

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manufacturing firms to concentrate on system design and final assembly and thus to restrict their R&D primarily to product design and process innovations for final assembly. Suppliers, in turn, can focus their limited resources on product and process innovations for parts and components and thus can aspire to accumulate specialized technological capabilities. See, for instance: Antonelli (ed.)[1989]; Imai and Baba [1991]; Antonelli and Foray[1991]; Sabel et al. [1991]; Bieber et al. [1991]; OECD [1992a], chapter 3, Ernst [1994a] [1997a] and (1997c).

54 The following is based on discussions with Dr. Lee Won-Young from the Science & Technology Policy Institute (STEPI), Seoul, Korea. See also Lee Won-Young (1995). See also OECD (1995a and b).

55 In principle, two institutions are supposed to exercise control: the Inter-Ministerial Council of Science and Technology and the Ministry of Finance`s Budget Office. In reality however both institutions are ill-equipped to guarantee effective coordination. The Council does not have much influence on the decisions of the Budget Office, with the result that few ministries bother to consult the Council before requesting their R&D budget. And the Budget Office, being woefully

society. For instance, the share of defense technology has been increasing from roughly 21% in 1990 to 27% in 1994 and is now the second largest component of the R&D budget. There have been various attempts to overcome this lack of coordination: the Ministry of Science& Technology (MOST) for instance has prepared a Long-Term Plan on Science and Technology toward the Year 2010. But none of these moves have changed very much.

As long as the goal was catching-up, Korea almost exclusively relied on one set of actors: the government research institutes (GRIs). Their main purpose was to compensate for the then still very weak R&D activities of private firms and to assist and support them in the assimilation and adaptation of imported foreign technologies. We have seen that this has changed since the mid-1980s, with the result that the private sector is now responsible for more than 80% of Korea´s total R&D. But this private R&D has a very narrow focus: most of it is geared to development rather than research, especially process re-engineering and product customization. This leads to a paradoxical result: The chaebol which have the funds for research, neglect it and prefer to focus on development activities. This is also reflected in their recruitment policies: only 8% of the Korean PhD holders work for private firms. This has led to a wasteful vicious circle of blocking research needed for industrial upgrading. The main cause is a fundamental mismatch in the allocation of R&D funds and recruitment. Nearly 80% of the government´s civilian R&D funds go to GRIs. This is much higher than even in France and Japan - two countries where the government traditionally has played a strong role in the national innovation system. Yet, due to the recent deterioriation of salaries and social status in GRIs, there is now a heavy brain drain from GRIs to universities. Korean universities which employ 76% of the PhD holders, however lack the research facilities and funds to conduct serious research: receiving less than 11% of the government civilian R&D funds, Korean universities are in a much weaker position than even in Japan, where universities are also quite weak in terms of R&D. Such fundamental imbalances in the allocation of human resoruces (researchers) and research funds have led to a tremendous wastage of the country´s most precious resources - a system that addressed extremely well the requirements of catching-up,

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under-staffed and lacking science and technology experts, is hardly qualified to make the right decisions.

is incapable of generating a critical mass of domestic research that is needed for successful industrial upgrading.

A further important weakness of the Korean innovation system, paradoxically enough, relates to the established educational system. Its heavy focus on the training of mid-level managers, engineers and technicians has been an important prerequisite of success during the catching-up phase. Yet today, as the focus shifts to research, product design and market development, the educational system is poorly equipped to cope with these new requirements. Korea´s educational system is characterized by a heavy reliance on formal education: in each field, the focus is on more classical material rather than more recent debates. Too much focus is placed on conformity and memorization, too little on creativity, i.e. the identification of new problems and innovative, i.e. unconventional solutions (OECD, 1995b). Higher education has remained a glaring bottleneck: underinvestment in education has resulted in a major bottleneck in Korea´s technological learning[56].

Probably of even greater importance than a lack of money is an outdated approach to organization:" an extremely unparticipative educational process with strong rigidities does not favor creativity and initiative. Most, if not all universities have deficiencies in establishing a critical mass to become first-rate research institutes owing to heavy teaching loads, lack of sufficient state-of-the-art equipment, and inadequate research support." (Kim Linsu, 1997b, p.27) This has two important negative consequences: Korea´s low level of higher education has been a major drag on R&D productivity in Korean firms. Of equal importance is that universities have not been able to play an incubator role for innovative start-up companies.

In short, as a result of its earlier success, Korea's innovation system is now faced with new challenges. It is characterized by a number of structural weaknesses, which by now have been well identified and extensively debated within both the government and management circles. Yet the inertia resulting from previous success and established power structures appear to cripple Korea's ability to adapt to the new industrial upgrading requirements. The search for a new policy doctrine and new corporate strategies remains constrained by a highly unequal distribution of

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56 "The problem of under-investment is most acute at the university level… (As a result), all but a few universities have remained primarily undergraduate teaching-oriented rather than research-oriented. " (Kim Linsu (1997b, p.10))

economic and political power. We now turn to such structural causes for Korea´s truncated industrial upgrading.

II.4. Korea´s high-debt -growth model

One particularly disturbing feature of Korea´s development model is a disproportionately high debt: Korea´s chaebol on average have a debt-equity ratio of 4 to 1[57]; and Korea´s total debts are estimated to be twice as large as its GDP of $ 500 billion[58]. It has been argued that such high debt is a necessary consequence of successful catching-up (Veneroso and Wade, 1998). High debt reflects large savings as well as the huge investments required for rapid capacity and market share expansion[59]. It is argued furthermore that catching-up "… is possible only through borrowings. Neither equity markets nor corporate retained earnings are feasible alternatives for mobilizing resources on the required scale. And equity finance is more expensive than debt finance, because of the need to pay a risk premium." (p.3) Successful catching-up thus requires a financial system that allows firms to borrow multiples of their equity: successful catching-up necessitates high debt-equity ratios. The consequence is a financial system that is highly vulnerable to shocks that interrupt cash flows or funding sources. State intervention - including financial regulation - is critical in order to reduce such vulnerability: "… there is… a strong financial rationale for cooperative, long-term, reciprocal relations between firms, banks and governments in a system with high savings and high debt/equity ratios." (Venerosos and Wade, 1998, p.2) A regulated financial sector is an essential prerequisite for sustaining the Korean development model. This analysis implies that the IMF approach with its focus on financial deregulation[60] violates an

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57 Of the top 30 chaebol, ten have a debt-to-equity ratio of more than five-to-one (The Economist, November 29, 1997, p.24). For 1996, the following debt-equity ratios have been reported by SBC Warburg Dillon Reed: Samsung (473 %), Hyundai (453%), LG (378%), and Daewoo (316%), as quoted in the Financial Times, January 22, 1998, p.5. Such figures however may underestimate the real debt burden: for instance Daewoo Motors, the dominant division of the Daewoo group, at the end of 1996 reportedly had accumulated debts of Won 4500 billion ($ 18 billion), or nearly six times equity (quoted in the Financial Times, December 4, 1997).

58 Standard & Poor estimates, as quoted in the Financial Times, February 3, 1998, p.16.

59 Gerschenkron (1962) remains the classical source on the capital requirements of late industrialization and the role of banks.

60 One key element of the IMF´s Asian Rescue Package is financial deregulation: the goal is to make the financial system operate like the Anglo-Saxon financial system. Apart from closing down troubled financial institutions and the introduction of Western lending and accounting standards,

essential stability condition of Korea´s high debt development model: it destroys the base for close cooperation between banks, firms and the government. The result is that financial deregulation will intensify rather than solve the current crisis. Financial deregulation is the wrong prescription: " even if a "western" look-alike system is established it would not be stable, given the high flow of savings. It would also sacrifice the very big developmental advantages of a high debt system." (ibid., p.6) In short, the solution proposed by the IMF is part of the problem; it will not help Korea to solve its most fundamental problem: how to use its huge savings productively.

This line of argument sounds convincing, in so far as it explains what happened during the period of catching-up . I agree with the authors` assessment of the disastrous and largely unrecognised risks of the IMF approach. But their argument also has two important weaknesses: it fails to explain why debt-equity ratios are much lower among Taiwanese companies; and it fails to address some negative consequences of high debt for firm strategies and industrial upgrading.

i) Are high debt-equity ratios really unavoidable?

Let us first look at the question whether high debt-equity ratios are an unavoidable feature of catching-up. In his earlier important book on "Governing the Market: Economic Theory and the Role of Governments in East Asian Industrialization" (1990, page 160), Robert Wade acknowledges that Korea´s corporate debt-equity ratio has been widely reported to be substantially higher than Taiwan´s ratio[61]. He argues however that "…the "true" Korean figure is probably much lower than its official value because of complications introduced by Korea´s higher inflation rate and higher permitted rates of accelerated depreciation" (ibid.), quoting a World

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financial deregulation essentially centres on two issues: i) a termination of government interventions; and ii) a further opening of the capital account. The first requires the government to stop intervening in the lending decisions of commercial banks, to eliminate all government-directed lending, and to give up measures to assist individual corporations avoid bankruptcy, including subsidized credit and tax privileges. Opening the capital account in turn is the pendant to trade liberalization: the aim is to foster the free inflow and outflow of capital, both portfolio capital and direct investment.

61 Wade (1990) quotes figures from Scitovsky (1986: chart 1) showing that, in most years between 1971 and 1980, Korea´s corporate sector debt to equity was between 310 and 380, while Taiwan´s ratio was much lower between 160 and 180. This is consistent with more recent figures quoted in Fields (1995: table 4-5) which show that in 1985, the debt-equity ratio of Korean manufacturing

Bank study on Korea (World Bank 1984, p.238, note 8) that puts the real Korean figure in the same order of magnitude as Taiwan´s official figure[62]. Wade concludes that there is a strong similarity between Taiwan and Korea in that "financing choices have been weighed heavily in favor of debt rather than equity." (Wade, 1990, p.160)

I do not agree with this conclusion. While international comparisons of debt/equity ratios are certainly plagued by methodological problems, it is not very convincing to assume that this can explain away huge differences that range from two-to-one (Scitovsky (1986)) to almost three-to-one (Fields (1995)). I would conclude from these figures that differences in debt-equity ratios are real and need to be explained by differences in industrial policies and in the nature of targeted industries in both countries[63]. Though Korea and Taiwan share many similarities, the two countries have chosen very different approaches. An important difference that sets apart Taiwan´s industrial policies from those pursued in Korea is that directed credit has played a much less important role, at least until the early 1980s (Inoue 1993: 14; Schive 1993: p.14; and San Gee 1995). This can be seen from the high real interest rates for secured loans that Taiwanese firms had to pay during this period[64]. This has changed only since the mid-1980s, when the focus of industrial policy shifted to industrial upgrading. One should also mention that curb markets have arguably played a more important role in Taiwan than in Korea as an alternative source of debt finance relative to bank credit (Pyung Joo Kim 1994: 284 following).

Probably of greatest importance however is that, unlike in Korea, Taiwan´s industrial policy did not discriminate against smaller firms: any firm, irrespective of size, could participate in industrial promotion programmes, including concessionary credit. In contrast to the Korean government which used its control of the finance sector to direct credit to a handful of chaebol, the Taiwanese government did not try

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firms was nearly 350, relative to a ratio of 120 for Taiwan. See also the figures quoted in Patrick and Park (1994), and in Ranis (1998).

62 This is ironic, given the fact that the World Bank today stresses Korea´s high debt ratio as one of the root causes of its crisis.

63 The following is based on Schive (1993), San Gee (1995). San Gee and Wen-jeng Kuo (1998), and Ernst (1998b).

64 San Gee (1995), table 4. The real interest rates for secured loans in Taiwan were 14.14%, 9.0 %, 8.05% and 9.7% respectively in 1965, 1970, 1975 and 1985. There was only one exception: in

to promote large national champions[65]. In this sense, Taiwan´s industrial policy is focused on flexibility and competition: relatively low entry barriers and non-discriminatory policies enable small firms to enter targeted sectors and to grow. At the same time, the legal system puts relatively few obstacles in the way of bankruptcy (Bee Yan Aw, Xiaomin Chen and Mark J. Roberts (1997)). In other words, flexibility has two aspects: Taiwan makes it easy for new companies to get started, and for established ones to fail. Combined, both factors have forced incumbents to stay trim; they have also accelerated the spread of information, skills and knowledge.

ii) Impact on firm strategies

The result is that Taiwan´s smaller companies had to rely more on equity markets and corporate retained earnings than the chaebol: Taiwanese firms find it more difficult to raise capital for large-scale volume production and they are under much greater pressure to submit investment decisions to short-term financial considerations. In the electronics industry, this has led to very different corporate strategies from those pursued by the Korean chaebol[66]. It has forced Taiwanese firms to respond more quickly to new market opportunities. It has been argued however that directed credit has given Korean chaebol a substantial long-term advantage in capital-intensive industries as well as in high-tech industries like electronics (Mody (1989) and Bloom (1992)). Yet, evidence on this matter is inconclusive. Yoo (1990) for instance has found that, despite the credit preference given to heavy and chemical industries in Korea, the two countries were roughly equally successful in increasing their export shares to the OECD in heavy and chemical industries. Directed credit obviously made a difference in “high-tech

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1980, the rate fell to -2.80, which was primarily due to the second oil crisis in that year. Note that these figures are adjusted for inflationary effects.

65 After the second world war, the Taiwanese government took over the Japanese enterprises that had been established during the 50 years of colonial rule (1895-1945). In contrast to Korea, the government did not privatize these firms. Instead, they were run as public enterprises. By developing a strong public enterprise sector, Taiwan developed companies large enough to enter the highly capital-intensive production of basic materials, while at the same time avoiding the dominance of private conglomerates. (San Gee and Wen-jeng Kuo, 1998)

66 The following is based on Ernst (1998b).

commodities" like semiconductors and liquid crystal displays. On the other hand, in most sectors of the computer industry, Korean chaebol keep lagging well behind their much smaller Taiwanese competitors, despite their privileged access to directed credit[67].

In short, it is probably misleading to argue that catching-up of necessity requires high debt-equity ratios. If at all, this claim has a certain plausibility for those sectors that are characterized by extremely high investment thresholds and risks, and where the focus primarily is on homogeneous products (like DRAMs and advanced displays). Access to directed credit however is unlikely to make much of a difference in sectors where quick response to changing markets and technology plus strong design capabilities are critical (i.e. a variety of sectors of the computer industry). In those sectors, it may in fact be detrimental in that it constrains speed of response and flexibility.

In the case of Taiwan, limited access to patient capital appears to have led to a product specialization that is more complex and sophisticated than in Korea. An important difference is an overwhelming focus on computer-related products, components and services. Within this sector, Taiwanese firms cover a much broader range of products than Korea: they are strong not only in design-intensive, differentiated products but also in homogeneous products. As for the latter , the main strength of Taiwanese firms is a capacity for quick response to changing market requirements. Over the last few years, Taiwanese firms have been able to supplement this with a capacity to coordinate complex international production networks for leading American and Japanese companies. At the same time, successful niche market strategies have been developed for differentiated, design-intensive hardware products as well knowledge-intensive support services.

For key components, large-scale projects do exist, but they are less dominating for Taiwan´s electronics industry than in the Korean case. Also, for these projects Taiwanese firms apparently rely more on joint ventures and partnerships with foreign firms. Outside of key components, mass production plays a much less important role than in Korea. As speed of response to changing markets is

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[67] Ernst (1998b) offers a possible explanation to this puzzle. It is argued that a general reluctance of the private sector in Taiwan to engage in R&D has been compensated by innovative institutions

considered to be a major asset, flexible specialization plays an important role for firm organization and supplier networks. Taiwanese firms normally avoid investing into leading-edge machinery, preferring well-proven equipment generations that facilitate quick ramping-up and that reduce uncertainty. Based on mature production technology, much greater emphasis is placed on quick changes in product design and organizational innovations related to logistics and global supply chain management. For instance, Taiwanese firms together with two American market leaders (Compaq and Dell) today are the pace-setters for the shift to order-based production systems in the computer industry.

Important differences also exist with regard to market entry: Taiwanese firms normally prefer a gradual step-by-step approach which is conducive for cumulative learning. Taiwanese firms consistently avoid vertical integration, and prefer instead to rely on complex international production networks. A lack of vertical integration is perceived to have substantial advantages. The fact that key components and engineering talent have to be purchased on the open market is perceived to enhance a firm´s flexibility if the technology changes rapidly. In such a case, a heavy reliance on internal sourcing would obstruct the firm´s capacity for quick response: its products would loose out to competing products that are able to design-in the latest generation of high-performance components; and the firm could end up with obsolete and undifferentiated skills[68].

Compare this with the very different approaches pursued by the chaebol: strategic considerations rather than profitability determine investment decisions and timing and sequencing of entry strategies, especially for key components (like DRAMs and advanced displays). One is to reduce dependence on foreign component sources, especially from Japan; another is to broaden the scope for diversification through vertical integration. While both motivations sound plausible, they should not be taken at face value. A heavy reliance on foreign component sources may not always be a disadvantage. Take the example of advanced displays, where Korean producers heavily depend on Japanese suppliers, but, nevertheless, "… were not so worried

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and various support policies for R&D and training, as well as by the early integration of taiwanese firms into international production networks.

[68] This is in line with the "externalisation" argument proposed by the evolutionary theory of the firm (see Langlois 1992; and Langlois and Robertson 1995)

about dependence on Japanese suppliers and … had mostly good experiences in working with Japanese companies." (Linden et al, 1997, p.26)[69]. There is also strong evidence that intended downstream integration effects have not materialized. Take for instance Samsung´s claim that its huge investments into the production of advanced displays is justified by improving the position of AST Research, an ailing American PC producer that Samsung had purchased in 1996. While Samsung invested substantial amounts in AST, this strategy today is in shambles, as AST keeps rapidly losing market share and has now become a marginal player[70].

Easy access to patient debt capital also explains a strong preference of the chaebol for vertical integration: it is perceived to have a number of important advantages for the procurement of key components and for the availability of skills, as well as for technological learning. For procurement, vertical integration helps to reduce the threat of periodic supply shortages; it provides a differentiation advantage through access to internally developed high-performance components; and it can strengthen the position of downstream divisions that are users of these components. For skills, vertical integration implies that each chaebol covers an extremely broad range of activities and can re-assign engineers with the necessary skills based on the strategic objectives of the group. As a variety of skills can be developed within the chaebol, this allows for an internalization of technological learning. Furthermore, vertical integration is expected to have a systemic effect on the reduction of technology gaps, especially for key components that are sensitive to learning economies[71] .

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69 A heavy reliance on component imports however becomes a serious problem, when devaluation of the local currency leads to drastic price increases.

70 Another example of unrealized downstream integration efforts is LG´s "strategic alliance" with DEC to supply advanced displays for jointly developed notebooks that would be marketed by DEC ("LG to Export Notebooks to DEC on OEM Basis", Korea Herald, August 20, 1997)

71 A typical claim for instance is that early entry into DRAM production of one division has facilitated a chaebol`s later entry into advanced displays. (Asia IT Report, "South Korea´s Monitor Industry in 1996", Market Intelligence Center, Institute for Information Industry, Taipei, September 1997.)

iii) Negative implications for industrial upgrading

Korea´s development model has been predicated on high and growing high debt-equity ratios. While it has produced extremely positive results in terms of rapid catching-up, it now has ceased to be a realistic option, simply because such high debt has become unsustainable. A brief comparison with the very different development pattern in Taiwan has shown that successful catching-up may also be possible without high debt. This of course does not imply that Korea should try to imitate Taiwan´s development model. What it does imply however is that a return to and a consolidation of Korea´s traditional high debt growth model is neither necessary nor feasible[72]. In my view, Venerosos and Wade (1998) unnecessarily reduce the options open to Korea to a much too narrow dichotomy. The issue is not simply whether Korea and other Asian countries should " give up developmental advantages of a high debt system in return for lower risks of financial crashes."(p.8) The real issue is: What changes are necessary in the development model that has been successful for a certain period of time, but now has blocked a further industrial upgrading?

If one chooses such an optic, one will find that *the link between growth and debt is not cast in iron: change is possible and in fact unavoidable and requires a paradigm shift in the development model.* Industrial upgrading essentially implies that a country can improve its capacity to use its savings productively. Accumulation of capital matters, but it needs to be complemented with something more qualitative: a capacity to learn and innovate [73]. Research in OECD countries has shown that the capability to learn determines the economic success, not only of firms and industries, but also of whole regions (industrial districts) and countries (OECD, 1996a, 1996b and 1996c)[74]. Combining the requirements of both

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[72] Implications for Korea´s strategic options are discussed in part III..

[73] This is in line with the findings of growth and innovation theorists who, while using different terminologies, all argue that investment needs to be complemented by learning and the formation of capabilities, in order to achieve sustained development. Important sources are: Schumpeter (1912); Avramovitz (1989), Freeman (1987), Lundvall (1992), Nelson (1992), Bell and Pavitt (1993) and Nelson and Pack (1995). This of course implies that accumulation theorists (Young , 1993; Kim and Lau, 1994; and Krugman,1994), for whom growth is largely a result of "a rapid movement along prevailing production functions" (Krugman (1994)), are taking a much too narrow view.

[74] This has given rise to the concept of the "learning economy" which argues that learning is an interactive, socially embedded process and that its efficiency crucially depends on the

accumulation and learning is a major challenge: it requires a set of institutions, incentives and policies that can mobilize huge savings and put them to productive use, while at the same time promoting a domestic knowledge base that is broad enough to facilitate industrial upgrading.

We have seen that, while Korea´s traditional development model was conducive for the needs of catching-up, i.e. rapid capacity and market share expansion, it has failed to develop a broad domestic knowledge base that is essential for industrial upgrading. We have also seen evidence of the resulting sticky pattern of specialization. Truncated industrial upgrading implies a precarious capacity to use savings productively. This is one of the dark sides of the Korean model[75] which has been neglected for far too long by scholars (like myself) who otherwise were right in defending some of its historical achievements against neoclassical orthodoxy.

There is ample evidence that Korea´s system of state-led development has given rise to a substantial wastage of capital. One general indicator that there is a problem is the marginal capital output ratio, a proxy for measuring the productivity of capital: "With an average annual savings rate of 30 percent and an average annual increase in the national income of 8 percent,…(Korea´s)…marginal capital output ratio has been in the range of four to five – not especially low when compared with other developing countries. … The implication is that the growth achievement could have been even more impressive if the resources of a disciplined labor force and a large increase in new plants and equipment had been combined more efficiently." (Aliber, 1994, p.342)

Badly implemented financial regulation that avoids public control has a built-in tendency toward over-lending and over-production. The basic mechanism is well documented in Kim Pyung Joo´s study of the development of Korea´s financial institutions (1994). Government-controlled finance has prevented the banking sector from from playing a competent coordinating role: "… banks´ profits have been illusory and frequently manipulated by the payment of interest on reserve deposits with the central bank" (ibid, p.292). Its raison d´etre has been to channel

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institutional set-up, the national innovation system. Lundvall and Johnson (1994) and Lundvall (1995) and (1996). For an application of this theoretical framework to developing countries, see Ernst and Lundvall (1997).

75 Another dark side of the Korean model of course has been the suppression of workers´ and civil rights that results from a command-type, forced industrialization.

financial resources to a handful of chaebol. The primary objective has been growth (or sales) maximization rather than profitability. “The goal was for enterprises to grow at top speed to achieve a critical minimum size, at which the government would be unable to allow insolvency or bankruptcy. … Fuel for the rapid expansion of firms was provided by high leverage or heavy dependence on debt financing. Firms raced to the brink of bankruptcy with one eye ever fixed on the government, which played the role of referee in this game of brinkmanship. It exercised discretionary power for determining which firm would get the benefit of financial credit and thus be saved from going over the edge. Thus, the maintenance of a good relationship with the government was the most crucial element for success in business. … A natural and inevitable consequence … was the increase in insolvent firms or non-performing assets on the balance sheets of the banks.” (ibid., pages 283 and 284)

The result has been a persistent tendency towards over-capacity in major growth industries such as ship-building, automobiles and semiconductors[76]. Directed credit is also prone to periodic waves of land speculation: “bank credit was extended normally on the basis of client firms´ real estate collateral instead of their credit standing, which tended to bring into motion a cumulative process of bank loans utilized for the acquisition of more real estate, which in turn led to further bank credit next round.” (Kim Pyung Joo, (1994), p.284) This has led to a “bubble economy” effect similar to the one that has hit Japan earlier on. Leading chaebol have played a major role in such unproductive use of capital. Take for instance the Samsung group. In 1996, Samsung´s debt equity ration was reported as 473%[77]. In a statement prepared to counter the request of the incoming administration of president-elect Kim Dae Jung that the chaebol should rationalize their assets, Samsung said that it would reduce its debt to 150% of its equity in part through sales of real estate valued at about $ 300 million, plus the cancellation of plans to build a 102-story headquarters building in a posh area in southern Seoul, valued at

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[76] For evidence, see Lee Suh-Chae (1991) for the HCI (Heavy and Chemical Industrialization) plan; and Jun Yong Wook and Kim Sang Goh (1990) for the electronics industry. For the car industry, see Motor Business Asia-Pacific Quarter 1, 1998 , Economist Intelligence Unit, as quoted in the Financial Times, February 2, 1998, p.3)

[77] Courtesy of SBC Warburg Dillon Reed, as quoted in Financial Times, Janauary 22, 1998, p.5.

about three trillion won ($ 1.83 billion), although it will not sell the massive plot of land[78].

In short, it is possible to argue that a substantial share of savings has not been used productively. Government pressure and guarantees, combined with poor regulations have led to distorted investment decisions, encouraging banks to finance risky projects in the expectation that they would enjoy the profits, if any, while the government would cover serious losses. This of necessity leads to over-investment, and the price of assets that are in limited supply, such as land and skills, will rise excessively. This bubble persists as long as the government guarantee is credibly maintained. The first bank that fails gets bailed out, but the costs of bail-out keep rising with each new bail-out, which reduces the government´s capacity to provide future rescues. Sooner or later, this will invite speculative attacks on the domestic currency (as demonstrated by Krugman, (1998)).

II.5. An unbalanced industry structure

Let us now turn to a second cause of truncated upgrading: Korea´s extremely unbalanced industry structure. A distinguishing feature of the Korean model is a dominance of large business groups that is unrivalled by other counties[79]: the combined sales of the five largest chaebol as a share of GNP grew from 12.8% in 1975 to 35% in 1980 and to a mind-boggling 52.4% in 1984 (Kim Linsu (1993), p.2). The chaebol dominate sales and exports; they can recruit the best workers, technicians, engineers and managers; they have privileged access to investment capital; and their strategies determine the product mix and the capabilities of Korea´s industry.

In the electronics industry, one important difference that distinguishes Korea´s approach from the Japanese model is the extreme degree of concentration which is much higher than in Japan (Kohama and Urata:1993, 152). Korea's electronics industry is controlled by four companies -- Samsung, LG, Hyundai and Daewoo. In

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78 The Wall Street Journal, 22 January 1998, p.3

79 The only exception is Sweden, where the Wallenberg group, through its holding company Investor, controls companies accounting for more than 40% of the Swedish market, while holding only 4 % of the capital. (“Reform from above at Investor”, Financial Times, January 28, 1998.

1988, 56 per cent of the country's electronics production came from these four groups, with the first two alone accounting for 46 per cent of production (Bloom:1992, p. 12). The figures are even more remarkable on an item-by-item basis with Samsung, Lucky-Goldstar and Daewoo accounting for 100 per cent of the VCRs, microwave ovens, refrigerators and washing machines and 82.2 per cent of the CTVs produced locally (Bark:1991, 32).[80]

Sellers' concentration ratios in the domestic market are even higher: until the early 1990s, Samsung, Goldstar and Daewoo had control over roughly 70 per cent of the Korean market (Jun Yong Wook and Kim Sang Goh (1990). For CTVs, VCRs, microwave ovens, refrigerators and washing machines, the Big Three's domestic market share came close to 100 per cent. Due to the gradual liberalization of the domestic market for consumer goods and industrial electronics, this tight control of the domestic market is now beginning to erode. Yet while the chaebol may lose control over final product markets, their dominant position in components, and especially DRAM memories, may last much longer. In 1992 for instance, the total semiconductor and electronics sale of one company alone, Samsung Electronics, accounted for 20 per cent of the Korean electronics industry's exports.[81] None of the big electronics groups in Japan comes close to such an overwhelming position of dominance. In short, the Korean electronics industry retains a structure which, according to textbook wisdom, is no longer supposed to exist: a tight national oligopoly controls both domestic production and the domestic market.

i) Implications for corporate strategy: "octopus-like diversification"

Korea´s unbalanced industry structure has given rise to a peculiar form of competition strategy that focuses on incessant product diversification, often into technologically unrelated areas[82]. Each time a chaebol has reached the limits of "easy" capacity and market share expansion for a particular product, it moved on to

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80 Hyundai, a latecomer to the electronics industry, has concentrated on components and industrial electronics and has no activities in consumer electronics.

81 Dataquest, Vendor Profile Samsung Electronics Co. Ltd, San José, Ca., September 20, 1993, page1

82 Literally translated, a chaebol means a "financial clique", and is defined as "… a business group consisting of large companies, which are owned and managed by family members or relatives in many diversified business areas." (Yoo and Lee (1987), p.97)

a new product group that promises rapid market expansion. In Korea, such “opctopus-like diversification has been pushed to the extreme: the top five chaebol are in an average of 140 different sectors each. No other country, not even Japan and Sweden, comes close to such an extreme reliance on unrelated diversification.

Here lies one of the most important differences between chaebol--type business strategies and those pursued by the Japanese electronics firms, which typically have been reluctant to engage in product diversification. A survey of the 200 largest Japanese industrial firms undertaken by Fruin (1992, p. 318) shows that only 40 per cent of them engaged in a limited amount of diversification, with 41 per cent of new goods being in the same two-digit SIC category as the firm's established products[83]. Gerlach (1993) has also shown that Japanese diversification has predominantly resulted in the "spinning-off" of new subsidiaries that retain a certain degree of decision autonomy from the parent company. At least for the electronics industry, there are grounds for challenging Amsden's claim that constant "... diversification into many technologically unrelated mature product markets was one of the essential "pillars" of Korea's successful late industrialization and that, in doing so, it was dutifully following the earlier Japanese example" (Amsden (1993), pages 17 and 18).

“Octopus-like” diversification has had important negative implications for capability formation. Rather than deepening their involvement in a particular sector or group of related products, the chaebol have typically used diversification as a short-cut to rapid market share expansion, without much concern for the depth of the production system that can be generated by such shallow forms of diversification. This "octopus--like" diversification has made it very difficult for most Korean companies to accumulate systematically a broad range of technological capabilities for a given set of products. It also has also left very little scope for an upgrading into higher-end market niches where perium prices could be reaped - a strategy perfected by Taiwanese firms. Finally, this opportunistic form of unrelated diversification has precluded a shift to technology diversification. Defined as “ the expansion of a company´s or a product´s technology base into a broader range of

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[83] The latter figure would in fact be higher -- 46 per cent -- if the United States SIC code did not classify computers in a different category (35) from other electrical devices (36 and 38).

technology areas" (Granstrand (1992, p.291), technology diversification is an attempt to reap technology-related economies of scope. It is arguably Korea´s best bet to proceed with industrial upgrading[84].

ii) A dearth of innovative small-and medium-sized enterprises (SMEs)

The pervasive role that the chaebol have played as engines of growth and industrial transformation sets Korea apart from Taiwan, where small-and medium-sized enterprises (SMEs) have been the main carriers of industrial development. Among Asian countries, Taiwan probably has made most progress towards a balanced industry structure that allows for close and flexible interaction between large business groups and SMEs: this has enabled small firms to grow and to respond quickly to changes in international markets and technology[85]; it may also explain why Taiwan has been able to shield itself much better than Korea from the financial melt-down that has swept through much of Asia.

Contrast this with the situation in Korea, where directed credit has consistently focused on the development of large domestic conglomerates. This has prevented the development of a vibrant domestic SME sector: until very recently, small, innovative start-up companies had little chances to gain access to such credit. In his important book on the dynamics of Korea´s technological learning, Kim Linsu argues (Kim Linsu, 1997a, pages 6 and 10): "The most serious consequence of the asymmetric promotion of chaebol was the impediment to the healthy growth of SMEs." "The government ... has been so preoccupied with mission-oriented projects (that were meant to create national champions, DE) that it failed to develop an effective infrastructure for SME promotion."[86]

The lack of a vibrant domestic network of SMEs has important negative consequences for learning and specialization. A key issue is whether a firm succeeds to move beyond imitation based on reverse engineering and moves on to apprentice-type learning where a link with a foreign company provides access to both tacit and explicit knowledge (Kim Linsu (1997a, pages 208 and 209). This distinction allows

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84 See our discussion in part III.

85 Ernst, 1998 b .

86 Only during the early 1980s did the government attempt to correct this major imbalance. There is general agreement however that much of this was too little and came too late.

us to highlight an important difference in technological learning between South Korea and Taiwan. In Korea, most SMEs continue to remain stuck with a focus on imitation based on reverse engineering (Kim Linsu (1997a), chapters 8 and 9). This has led to a very low learning efficiency of SMEs in Korea. The situation is radically different in Taiwan (Ernst (1998b)): especially in the computer industry, SMEs have been exposed early on to apprentice-type learning arrangements with large firms (both foreign and domestic) which has enabled them to move on rapidly from relatively simple to increasingly complex forms of international subcontracting.

The chaebol's dominance in the electronics industry also has had a negative effect on the role of SMEs engaged in the supply of parts and components and other complementary support activities. Although formally independent, most of them are tightly integrated into the production networks of one of the four major chaebol. Until the early 1980s, this had resulted in an industry structure where the leading chaebol tended to produce almost everything in-house, from electronics components and electrical accessories to transistors, semiconductors and precision engineering parts (Wong Poh Kam:1991, 53). Since then, they have been forced to increase their reliance on domestic subcontractors for two main reasons. In response to the proliferation of labour disputes since the famous wave of strikes in June 1987, the chaebol have shifted the burden of increasing labour costs onto the shoulders of formally independent domestic suppliers. At the same time, the growing sophistication of Korea's electronics production has increased the demand for local support industries and services. With intensifying price competition, the chaebol are now more willing to outsource some of these activities. One peculiar feature of the Korean electronics industry is that subcontractors work only for one manufacturer and are thus locked into a fairly closed production network controlled by a particular chaebol. Small- and medium-sized suppliers have very limited decision-making autonomy, which significantly limits any attempts to improve their international competitiveness.

An equally important concern is the extreme concentration of private R&D. It is estimated that the five leading chaebol currently account for nearly 37% of Korea´s total R&D investment in the private sector; the ten leading chaebol for nearly 45%; and the twenty leading chaebol for more than 53% (Oki, Toshie (1993), p.46) The same study found that in the U.S. and Japan the share of the 20 leading firms in total

R&D investment was less than 31% and less than 37%. There is no doubt that chaebol control the key assets and capabilities of Korea's innovation system. The result is that science and technology decisions continue to be overwhelmingly shaped by the strategies of the leading chaebol. This obviously puts Korean SMEs at a major disadvantage, and thus perpetuates Korea´s extremely unbalanced industry structure. Take, for instance, access to human resources. The leading scientists and engineers recruited for the chaebol's R&D centers and technology planning posts with but few exceptions are all foreign-educated PhDs often with extensive experience at major multinationals in the United States and Japan. This provides the chaebol with invaluable informal linkages with the major innovation clusters in the electronics industry. SMEs do not have any realístic chance to hire such people. This is another area which distinguishes Korea from Taiwan.

In recent years, the government has started to give greater attention to the promotion of SMEs capable of developing their own component designs. This has led to a variety of new policy instruments designed to improve the competitive conditions for innovative start-up companies.[87] Most observers agree that such policies have had only limited success. A recent survey by the School of Small Business at Soongsil University indicates that 70 per cent of government-allocated credit goes to a few relatively large SMEs with strong ties with the leading chaebol through subcontracting arrangements [88] . One particularly ironic finding is that many of these small businesses are becoming "mini-chaebol" by branching into various businesses but keeping each of the companies small to maintain access to cheap credit.

The independent SME sector will probably remain weak and vulnerable for some time to come. This sets Korea apart from the Japanese production system with its sophisticated multi-tier supplier networks, where small companies can be found at all levels with sound design and engineering capabilities for components and

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87 For example, the government has designated 205 business territories, the so--called "SME sanctuaries", where neither chaebol nor their affiliates may intrude. Attempts are being made to increase the share of total commercial bank loans for SMEs to 35 per cent through the so--called "compulsory lending ratio" and the government has initiated aggressive venture capital funding for product development by SMEs.

88 These findings were reported in the Far Eastern Economic Review, 19 November 1992, p. 70.

materials.[89] This lack of a strong domestic supplier network of SMEs also marks a major difference with Taiwan, where highly flexible domestic subcontracting networks based on SMEs have played a crucial role in the development of Taiwanese electronics exports (Ernst, 1998b).

Squeezed in between the chaebol and the myriad of SMEs are a handful of independent, medium-sized second-tier firms, each of which is basically organized again as a mini-chaebol. Typical examples of these second-tier firms include the Anam group, with Anam Industrial as its flagship company, and Trigem Computer. In an industry dominated by chaebol with their privileged access to government bureaucrats, both companies are able to survive only by identifying smaller, but lucrative niche markets that the chaebol have neglected. An additional prerequisite, it seems, has been a long-term relationship with a foreign company: Trigem Computer through its joint venture with Seiko Epson, and Anam through its link with its United States marketing affiliate, Amkor, the original founding company of Anam Industrial.

While Japan's electronics industry includes a number of originally small- or medium-sized, highly innovative start-up companies like Sony, Kyocera, Canon, Minebea or Uniden, the tight oligopoly governing the Korean electronics industry has made this almost impossible. A telling example of the constant frustration that innovative start-up companies encounter is that of a small computer design company, run by a group of eight engineers and computer scientists who knew each other since high school and who no longer wished to work in the highly regimented environment of the chaebol. After trying, without success, to sell some of their designs for pen and pocket computers to the chaebol, they ended up selling them to a second-tier Taiwanese PC assembler which, at least for a few months, is reported to have made healthy profits with these machines (Author's interviews, Korea, November 1993).

To conclude, a dearth of innovative and aggressive SMEs has severely constrained Korea´s attempts to develop higher-end niche markets, one important element of industrial upgrading. This again differs markedly from the situation in Taiwan,

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[89] Of the rich literature on the Japanese production system, see Dore (1973), McMillan (1985), Fruin (1992) and (1997), Kenney and Florida (1992), Gerlach (1993), Abo (ed.) (1993), Nishiguchi (1994), and Nonaka and Takeuchi (1995).

where SMEs have played an active role in developing such strategies. This also sets Korea apart from Japan where SMEs have played an important role in the development of the electronics industry. There is of course no doubt that the strength of the chaebol historically has been an important asset: a capacity to reap economies of scale and scope, combined with substantial cross-subsidization has facilitated rapid catching-up. But it fails to cope with the increasingly complex requirements of industrial upgrading. The strength of the chaebol however has turned into a burden simply because Korea today lacks a viable SME sector that can provide key components and critical complementary support services to the chaebol. The issue is not to get rid of the chaebol, but how to transform them, while at the same time developing a viable SME sector.

III. Options for Strategic Response: What Changes are Necessary in the Korean Model?

III.1. The vicious circle of truncated industrial upgrading

Our analysis of the evolution of technological learning in Korea´s electronics industry has highlighted some of the strengths and weaknesses of the Korean development model. We have seen how an exposure to high debt-equity ratios, combined with an extremely unbalanced industry structure, have led to a sticky pattern of specialization and a narrow domestic knowledge base. It is this vicious circle of truncated industrial upgrading that explains the extreme vulnerability of Korea to Asia´s financial crisis. The melt-down of Asian currencies and the turmoil in international financial markets have acted as a catalyst and determined the timing of the outbreak of the Korean crisis. Yet, it is due to the above structural weaknesses that these external factors had such a devastating effect.

It is important to remember that Korea already had serious problems *before* traders abandoned its currency. Since 1996, a reduction in export revenues combined with depressed domestic sales has led to a liquidity squeeze and bankruptcies of major chaebol. Large-scale strikes sparked by the government´s controversial attempts to push through legislation on labor law reforms have eroded social consensus. The result has been a massive reduction of domestic investment and consumer expenditures. In other words, Korea´s was already caught in a deflationary spiral,

and hence was already weakened when the financial crisis hit. A survey of the Korean economy, published well before the financial crisis, states unequivocally: "The South Korean economy is heading for a crisis as the growth that sustained the country´s outward-oriented expansion over the past three decades is beginning to run out of steam."[90] In 1997, truncated upgrading produced a record "corporate meltdown": 13,791 firms went bankrupt, most of them before the bursting of the Korea bubble. Among these firms are eight large chaebol, which sought bankruptcy-court protection with combined debts of 20 trillion Won ($21 billion)[91].

We have seen that the Korean model that was tremendously successful during the catching-up phase, has now reached its limits for two reasons: it generates unsustainable high debt-equity ratios, and it is out of touch with current industrial upgrading requirements. In part II of this paper, I have argued that attempts to return to the status quo ante will not provide a solution. Nor will the IMF approach. Since 1993, Korea has experienced a series of poorly designed and implemented liberalization policies that arguably have further aggravated some of Korea´s most serious structural deficiencies[92]: there is a lack of clear and enforceable rules; banks have been given much greater freedom to borrow overseas, which has dramatically deterioriated the maturity structure of Korea´s debt[93]; and traditional rules-based state-business relationships have degenerated into a Korean-style "cronyism".

These developments culminated during the summer of 1997, with the liquidity crisis of the Kia group, Korea´s third largest car producer and Korea´s eighth-largest chaebol. Bad management of the Kia crisis arguably has broken the confidence of international capital and currency markets in the Korean model. In response to Kia`s liquidity crisis, the government vacillated and dithered. A statement by the Ministry of Finance which refused to confirm an automatic bail-out was interpreted by the financial markets as an important coded message that from now on earlier bail-out

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90 "Focus. South Korea: Trade and Investment", Far Eastern Economic Review, October 23, 1997, p.70.

91 The Economist, January 24, 1998, p. 81.

92 The following is based on Chang Ha-Joon, 1998a and 1998b. Chang shows how poorly designed and implemented liberalization policies since 1993 have created a vaccum that has magnified the traditional weaknesses of the Korean model.

93 The share of short-term debt has been rapidly increasing from 43% in 1993 to 58.2% in 1996, and 58.0% in 1997. This is much higher than the non-OECD countries average of 20%.

guarantees would no longer hold. This is ironic, as the real motivation of this statement had to do with party politics. The demise of Kia was seen to improve the chances of Samsung to enter car manufacturing. This was in the interest of the government for two reasons: Samsung had developed close links with the Kim Young Sam administration; and it had agreed to locate its plant in the home province of the president, in Pusan. A traditional “pork barrel” deal thus was misinterpreted as a signal for radical liberalization. Given the turmoil in Asian currency markets, this had devastating effects on foreign investors.

In short, ill-conceived and mismanaged liberalization has accentuated some of Korea´s most serious structural deficiencies. This implies that attempts to return to the status quo ante will not provide a solution; nor will the IMF approach with its focus on deregulation. Korea can no longer afford to muddle through in a state of truncated upgrading, even once the current financial crisis will have subsided. This has important policy implications. While drastic changes in the financial system are important, they need to be supplemented with changes in the real economy: industrial upgrading is overdue, and this requires fundamental changes in the Korean model. A new round of policy and institutional innovations is required that can help to remove the barriers to industrial upgrading.

There were ample opportunities for such upgrading during the period of the high Yen. The fact is that, despite much talk, these opportunities have not been used. The tragedy is that the window of opportunity for making this move may now have been closed for a long time by the current debt and financial crisis. The IMF package unnecessarily increases such barriers to industrial upgrading. A radical break is required in the Korean development model: Korea now needs to move beyond a focus on quantitative development towards multi-faceted qualitative development which necessitates a broadening of the domestic knowledge base. A new round of policy and institutional innovations is required that can help to remove the barriers to industrial upgrading.

III.2. New competitive challenges

How important these upgrading requirements are can be seen when we look at some major changes in the competitive requirements that Korea´s electronics industry is

facing today. Probably the most immediate challenge is the decline of Korea´s market share in its major export markets in the U.S., Europe and Japan. To a large degree, this results from Korea´s sticky specialization on price-sensitive lower- end consumer devices and standard components, like DRAMs. Furthermore, new competitive challenges are now confronting Korea´s electronics industry, both from below and from above. From below, new, lower-cost competitors have emerged in China and Southeast Asia for consumer electronics as well as standard components; these new competitors include both offshore transplants of Japanese, American, Taiwanese and European firms as well as local firms. From above, established market leaders, especially for key components, are more and more reluctant to license technology to Korean firms: the closer Korean firms have moved to the technology frontier, the more constraints they face in their access to foreign technology[94].

A third important new challenge is that Korea´s electronics industry will face increasingly intense competition in its home market, as WTO-driven liberalization will proceed. Korea is now a member of the OECD, with the result that such liberalization pressures are bound to increase. This is of great importance, as high prices in the domestic market traditionally have enabled Korean firms to cross-subsidize their aggressive export pricing strategies. Furthermore, the domestic market traditionally has acted as a buffer against disruptions in export market growth: until recently, Korea´s domestic market has typically accounted for around 40% of all consumer electronics sales of Korean firms.

Finally, and by far of greatest importance are some fundamental changes in the nature of competition in the electronics industry[95]. Competition has globalized and become more knowledge-based, making it more difficult for firms to identify market niches and to grow with them. Competition centers around global standards that are set by a handful of powerful global market leaders, like Intel and Microsoft, giving rise to global oligopolies. Simultaneously, powerful forces have increased market volatility: there has been a dramatic increase in the pace of change and uncertainty

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[94] For an early analysis of these constraints, see Ernst and O`Connor (1992).

[95] I have analyzed these changes in detail in a study for the Alfred P.Sloan foundation (Ernst 1997c). See also Ernst 1997b and chapters I and II in Ernst and O´Connor, 1992.

related to technology and markets, with the result that competitive success is determined by the speed of response to such changes. Intense price competition needs to be combined with product differentiation, in a situation where continuous price wars erode profit margins. Of critical importance however is speed-to-market: getting the right product to the highest volume segment of the market right on time can provide huge profits. Being late is a disaster which quite frequently may force a company out of business[96]. As a result, competition today centers around a firm´s ability to build capabilities quicker and at less cost than its competitors (Kogut and Zander, (1993)).

Korean firms can no longer focus exclusively on price competition, but must simultaneously match best practice in quality, product innovation and speed-to-market. Under these competitive conditions, the static comparative advantage on which Korean firms have based their export success erodes more rapidly. It is clear that the chaebol´s hierarchical organization and top-down management approaches are ill-equipped to cope with these challenges: major changes are required in firm organization and industry structure in order to accelerate speed-to-market and in order to improve the capacity for flexible response to changing markets.

III.3. The limits to "muddling-through"

The financial crisis has dramatically reduced the access of Korean firms to patient debt capital. A return to the high-debt growth model clearly is no longer a realistic option. Nor is it very realistic to hope that exporting one´s way out of the crisis will be possible. "Muddling-through" has run its course.

Until around mid-1996, "muddling-through" did produce some remarkably positive results, basically for three reasons[97]: Of over-riding importance has been the substantial appreciation of the yen relative to the U.S. dollar, as a result of which the price competitiveness of Korean electronics products experienced an unexpected improvement. With the won's fall against the yen, Korean electronics firms were enjoying an export boom and taking business from Japanese competitors,

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96 On the importance of speed for product innovation, see Richardson, 1996, Anderson (1997), and Langlois and Steinmueller, 1997.

97 The following draws heavily on Ernst (1994 b, chapter 5.

particularly in price-sensitive market segments like DRAMs and lower-end consumer devices. A second important factor behind the relative success of muddling-through has been the cyclical boom of DRAM exports since 1993. In 1996, this boom however gave way to a severe bust, which ruthlessly exposed some of the fundamental structural weaknesses of this industry that I have discussed before. It clearly demonstrated that the Korean overdependence on DRAMs can be fatal, as this is the "bleeding-edge" of the semiconductor industry.

China has been a third and final reason for the attractiveness of muddling-through: since 1992 the floodgates to its huge market have been pushed wide open. Korean electronics companies with their focus on cheap household goods and audio-visual equipment were obviously able to reap substantial windfall profits from this new "China boom." Yet soon this easy phase of penetrating the Chinese market through direct exports came to an end, as the central government has clamped down on imports. Korean companies have felt the brunt of this import reduction, as their sales overwhelmingly depended on exports[98].

III.4. From Catching-up to Technology Diversification

This poses a major dilemma for the Korean electronics industry. How to upgrade its competitive position through improved product differentiation and market development capabilities, without losing its traditional strengths, i.e., the formidable mass production capabilities resulting from superior size and oligopolistic market control? In what follows, I will briefly sketch out one possible option for strategic response to the current crisis which, in my view, has received insufficient attention: an upgrading from product to technology diversification that broadens Korea´s knowledge base, but at the same time utilizes its traditional strengths[99].

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98 This is a reflection of the fact that Korean FDI in China is still relatively weak, especially when compared to the investments of their main Japanese and Taiwanese competitors. In fact, much of the benefits of China´s import substitution have been reaped by leading Japanese consumer electronics firms which, since 1992, have rushed to expand their Chinese transplant production activities (For details, see Ernst 1997a). The same is true for Taiwanese firms, and a few American companies in the computer industry.

99 Another option, chosen in particular by Taiwanese firms, would be to pursue a number of indirect entry strategies which focus on niche markets related to specialized needs and capabilities. It is however unrealistic to expect that Korea can successfully replicate such a strategy. The main reason are some peculiar features of Taiwan´s industry structure which, we have seen, are blatantly absent in the case of Korea. One is an extreme form of specialization of Taiwan´s

As Korean firms are approaching the limits of catching up, it is necessary to search for new approaches. The international environment in the 1990s is not nearly as welcoming to latecomers as that of the 1970s and early 1980s. In contrast to their Japanese, American and European counterparts, a medium-sized country like Korea, which only recently joined the international market, is less well-endowed to cope with the restrictions imposed on international trade, investment and technology flows due to the proliferation of “high-tech neo-mercantilism” (Ernst and O’Connor [1989], p.26 passim). As a result, head-on competition with market leaders in “high-end applications” is out of the question.

Rather than jumping right into "technological leadership" strategies, recent research has shown that industrial latecomers may have an intermediate option, i.e., technology diversification. Defined as “ the expansion of a company´s or a product´s technology base into a broader range of technology areas” (Granstrand (1992, p.291), such strategies are an attempt to reap technology-related economies of scope. Technology diversification differs quite substantially from so-called “technology leadership” strategies which are defined by their focus on products with a high R&D content (i.e., high R&D intensity or high R&D value-added). Instead, technology diversification focuses on products which are "... based on several... crucial technologies which do not have to be new to the world or difficult to acquire" (Granstrand (1992), p. 300). Empirical research on Japanese, U.S. and Swedish companies has demonstrated the relevance of this strategy: it has shown that "...technological coexistence is more predominant than technological substitution, as seen from the larger number of old technologies in a current product generation, compared to the number of obsolete technologies (Granstrand (1992), p. 305.).

Japanese firms have played a pioneering role in the development of technology diversification strategies. The underlying rationale has been threefold: an attempt to compensate for the increasing constraints on their existing manufacturing exports; a deliberate strategy to develop generic technologies that could form the base for

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domestic supply base; the second feature is a certain network structure of multiple, volatile and short-term links that involve only limited financial and technology transfers: Taiwan´s computer industry is based on extremely open and volatile production networks, arguably even more so than the highly flexible production networks that characterize California's Silicon Valley (For evidence and further sources, see Ernst (1998b))

penetrating future growth markets; and finally, a reaction to the increasing technological complexity and rising R&D cost of new products (Odagiri and Goto (1992)). For Korean electronics firms, technology diversification strategies could have a number of important advantages. It builds on existing strengths of Korea´s approach to technological learning. As technology diversification normally goes hand-in-hand with extensive reliance on external technology sourcing, Korean firms could make use of their accumulated capabilities in external technology sourcing, imitation and adaptive engineering. Technology diversification can also reduce the financial burden and high debt that result from over-ambitious "technology leadership" strategies. To the extent that their expenditures on R&D will be reduced by the financial crisis, technology diversification can help Korean firms to reduce these costs, and to spread them not only over many markets (countries and segments), but also over many products. Finally, technology diversification may also help to open up new windows of opportunity for international market penetration and for the development of new market niches. Given Korea's limited capacity to create generic technologies and to develop new products and markets, any attempt to follow the U.S. focus on "breakthrough" technologies would clearly be unrealistic, with the possible exception of semiconductor memory products. In most cases, Korean electronics firms would be well advised to pursue technology diversification strategies, which would enable them to build up gradually their capabilities for product and market development.

III.5. Conclusions

Leading chaebol claim that they have already vigorously moved into this direction. They point to a series of technology agreements with leading American and Japanese electronics producers and to a massive increase of R&D expenditures and productive investment. Since 1993, the four leading Korean electronics producers have indeed drastically increased their R&D and capital outlays; they were also planning to increase them even further before the crisis hit[100].

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[100] For evidence, see Ernst (1994 b), chapter 5. Over the last few years, all major chaebol have poured huge amounts of capital into R&D, with the result that the average ratio of R&D to sales has increased to 6%. For the Samsung group, that figure has reached 13%. If that figure is correct, that would be quite impressive: it would imply that Samsung substantially spends more

What is important however is not the amount of investment expenditures per se, but their allocation among different types of products and production activities. The real question is to what degree such investments have been used to correct some of the basic weaknesses of the Korean electronics industry that we have discussed before, especially with regard to product specialization, the organization of production and the accumulated technological capabilities. And here the empirical evidence speaks for itself. Since 1993, capital spending has been overwhelmingly concentrated on the rapid expansion of mass production lines for two products, i.e. computer memories and liquid crystal displays (LCDs). In 1994 for instance, Samsung has spent an estimated 80% of its investment total of $1.87 billion on just these two product groups. The respective ratios for Goldstar and Hyundai were even higher[101]. The huge capital spending binge of Korean electronics firms thus clearly has had the primary effect of consolidating the existing patterns of product specialization and production organization. Only in a very limited way will it be able to act as a catalyst for the substantial changes that we have argued before have long been overdue. In other words, more of the same rather than a shift to new products and production activities seems to be the common denominator of the most recent wave of capital spending.

This now needs to change. A radical paradigm shift is overdue, as Korea has reached the limits of the old export-led industrialization model with its emphasis on standardized mass production, OEM exporting and a catch-up mentality. Moving beyond these limits will require a number of fundamental changes in the Korean development model. This is true for government policies and industry structure, as well as for firm organization and strategies. There is an urgent need to redefine the

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on R&D, relative to sales, than for instance Canon which, with a little more than 10% of its sales revenues spent on R&D, is one of the leaders in Japan. In pure quantitative terms, Samsung thus is doing well. But there are two important differences: First, while debt is a major source for Samsung`s R&D expenditures, Japanese companies like Canon are very conservative and rely overwhelmingly on reinvested profits (Landers, Peter, "Quality counts. Technical prowess and global reach keep Japanese giants on top.", Far Eastern Economic Review, February 5, 1998). In other words, Samsung´s aggressive expansion of R&D expenditures comes at a heavy cost: what it may gain in terms of knowledge needs to be weighed against a substantially greater vulnerability to any crisis in the financial system. Second, in terms of the efficiency of technology management, there is no doubt that even Samsung, which is widely credited to be one of the best managed Korean chaebol, lags way behind its major Japanese competitors.

[101] It is reported that, for LCDs alone, Samsung, LG and Hyundai together had budgeted to spend roughly $4.5 billion between 1996 and 1998. (Linden et al, 1997)

role of government interventions[102]. The issue is not to reduce government intervention but what type of government intervention is necessary to overcome the barriers to industrial upgrading. Paradoxically, one particularly disquieting aspect of the Korean model is the weak role that government funding plays for R&D: whereas the share of government funding in R&D in Korea has been less than 20% since the late 1980s, the government`s share in Taiwan has remained about 50% (compared with about 30% in Japan and the U.S.). This did not matter, as long as the chaebol had easy access to patient capital and thus were able to fund rising R&D expenditures out of debt[103]. This is no longer the case, with the result that the chaebol will have to reduce drastically their R&D expenditures. This raises an important question: Will the government will be able to compensate for this decline in private R&D, for instance by reducing some of the gross inefficiencies in the public innovation system that we have discussed earlier?

In order to simply keep up with the new challenges of global competition, Korea needs to move ahead with industrial upgrading: of critical importance is the creation of a broad-based and diversified knowledge base for technology diversification, especially with regard to product design, market development, the production of key components and the provision of high-end knowledge intensive support services. Strengthening the financial and technological capabilities of domestic small- and medium-size enterprises (SMEs) is a third essential element of such a paradigm shift. Fourth, in order to improve their scope for learning and knowledge creation, Korea´s chaebol need to open up their hierarchical and centralized governance structures: an increase in the share of foreign ownership that is likely to result from the financial crisis, could play an important catalytic role[104]. Fifth, a selective liberalization of imports and inward FDI is essential for improving access to generic

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[102] For some thoughtful suggestions, see Chang Ha-Joon (1997and 1998a).

[103] Taiwan is in a completely different position. As its small firms were weak in terms of R&D, the government had to pioneer a number of institutional innovations and also had to play a more important financial role. While many mistakes have been made, overall the system has worked extremely well. There was enough time to learn from earlier mistakes and to establish an institutional framework and incentives that can generate the knowledge and externalities that Taiwanese electronics firms need in order to upgrade their industry (Ernst (1998b)).

[104] It is problematic to assume that an increase in foreign ownership of local assets is negative under all circumstances. After the second world war, Germany has been invaded by American capital: this has not prevented Germany´s development into a major economic power. Within certain

technologies and core components as well as for improving access to overseas markets. This reflects the fact that competition in the electronics industry is shaped primarily by "strategic games" among the leading companies or coalitions of firms, which position themselves so as to discourage or dictate the actions and responses of their competitors(Ernst and O`Connor, 1992, chapters I and II).. Such games are played on different levels, where cooperation often goes hand in hand with intense competition. Korea can no longer afford to stay out of such games.

Sixth, probably one of the most critical issues that Korea needs to face in the coming years is a redefinition of the link between local capability formation and international linkages[105]. This is true especially for a knowledge-intensive and highly globalized industry like electronics where clusters of local capabilities can no longer exist in isolation: they are rapidly becoming internationalized, either through acquisitions or through the increasing power of global customers. Leading multinationals in this industry construct international production networks (IPN), as they need quick access to lower-cost external capabilities that are complementary to their own competencies. In order to mobilize and harness these external capabilities, multinationals are forced to broaden their capability transfer to individual nodes of their IPN. International technology sourcing based on privileged links with major American and Japanese market leaders are an essential prerequisite for a continuous industrial upgrading of Korea´s electronics industry. This has important implications for government policies and firm strategies: a radical reversal is required in strategic priorities, away from an almost exclusive focus on the establishment of "national" institutions and linkages. Localized technological learning matters of course. Yet, "one should never overlook the opportunities of establishing and utilizing international linkages made …more feasible by … globalization.." (Chang Sei-Myung (1998), p.28) Finally, Korean electronics firms need to move beyond export-led international market penetration and to improve the balance between the location

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limits, foreign ownership in fact can help to accelerate necessary changes in outdated management approaches and firm organization. (UNCTAD 1995).

105 The following is based on Ernst (1997c and 1998c). This has also been a consensus position of an international working group meeting on "Globalization and Industrial Upgrading", established by the Social Science Research Council(SSRC), NewYork (SSRC (1997)). Participants in the meeting included L. Bruszt; J. Deeks; R. Doner; D. Ernst; G. Gereffi; A. Glasmeier; E. Hershberg; R. Kaplinsky; J. Katz; Tai Lok-lui; S. Martin; L. Mytelka; T. Ozawa; A. Parisotto; A. Saxenian; J.Sedaitis; and R. Wade.

of their markets and production sites by expanding and upgrading their international production networks in the United States, as well as in Asia and Europe.

The current crisis has established beyond doubt that such changes are overdue. New and innovative approaches are necessary to government policies and firm strategies that can help remove the barriers to industrial upgrading. All depends on whether key actors in government and industry are willing to take the necessary actions needed to fully make this transition.

Bibliography

Abo, T. (ed.) 1993, *Hybrid Factory. The Japanese Production System in the United States*, Oxford University Press

Aliber, R.Z., 1994, "Financial Reform in South Korea", in: Lee-Jay Cho and Yoon Hyung Kim (eds), *Korea´s Political Economy. An institutional Perspective*, Westview Press, Boulder etc.

Amsden, A. [1989], *Asia's Next Giant. South Korea and Late Industrialization*, Oxford University Press, New York etc.

Amsden, A., 1993, "The Japanese Model of Late Industrialization in other East Asian nations", paper presented to the workshop on "Japan as Techno-Economic Superpower: Implications for the United States", Centre for National Security Studies, Los Alamos National Laboratory, Santa Fe, New Mexico

Anderson, B. , 1997, " R&D Knowledge Creation as a Bazaar Economy", paper presented at the OECD Workshop on the Information Society, Institution of Electrical Engineers, London, May

Antonelli, C. (ed.) [1989], *New Information Technology and Industrial Change - The Italian Case*, Kluwer Academic Publishers, Dordrecht etc.

Antonelli,C. and D. Foray [1991], " Technological Clubs: Cooperation and Competition", paper presented at the 7th ThinkNet Commission Meeting, "Scenarios Toward a NetWorld Order", Paris

Arrow, K.J. (1962), "The Economic Implications of Learning by Doing", *Review of Economic Studies*, June

Asia IT Report, Market Intelligence Center, Institute for Information Industry, Taipei, various years

Avramovitz, Moses, 1989, *Thinking About Growth*, Cambridge University Press

Bark, T, 1991, "Anti-Dumping Restrictions against Korean Exports: Major Focus on Consumer Electronics Products", manuscript, Korea Institute for International Economic Policy, Seoul

Baumol, W.J., J.C. Panzer and R.D. Willig, 1982, *Contestable Markets and the Theory of Industrial Structure*, Harcourt Brace Jovanovich, New York

Bee Yan Aw, Xiaomin Chen and Mark J. Roberts, 1997, "Firm-level evidence on productivity differentials, turnover and exports in Taiwanese manufacturing", *NBER Working Paper 6235*, October

Bell, Martin and Keith Pavitt [1993], "Technological Accumulation and Industrial Growth: Contrasts Between Developed and Developing Countries:, *Industrial and Corporate Change*, Vol.2, No.2

Berger,S. and R. Dore (eds.), 1996, *National Diversity and Global Capitalism*, Cornell University Press, Ithaca and London

Bieber, D. et al [1991], "Autonomie and Beherrschung in Abnehmer-Zuliefererbeziehungen", in: H.G. Mendius et al (eds.), *Zulieferer im Netz*, Bund Verlag, Koeln (Cologne)

Bloom, M. [1992], *Technological Change in the Korean Electronics Industry*, Development Centre Studies, OECD, Paris

Boyer, R., 1996, "The Convergence Hypothesis Revisited: Globalization but Still the Century of Nations?", in: Berger,S. and R. Dore (eds.), 1996, *National Diversity and Global Capitalism*, Cornell University Press, Ithaca and London

Chang, Ha Joon, 1998a, "An Alternative View on Budgetary Reform in Korea. Dynamic Efficiency, Institutions and Political Economy", paper presented at a

conference on “Korea´s Transition to a High-Productivity Economy”, Korea Studies Centre, University of Hawaii at Manoa, Honolulu, Hawaii, USA

Chang Ha Joon 1998b, “Korea: The Misunderstood Crisis”, paper presented at the *Nordic Research Seminar on the Economic Crisis in East and Southeast Asia*, Centre for Development and the Environment (SUM), University of Oslo, Oslo, January 23-24

Chang Ha-Joon, 1997, “Globalisation, Transnational Corporations and Economic Development. Can the Developing Countries Pursue Strategic Industrial Policy in a Globalising World Economy?”, forthcoming (1998) in: D. Baker, G. Epstein and R. Pollin (eds.), *Globalisation and Progressive Economic Policy: What Are the real Constraints and Opporrtunities?*, Cambridge University Press, Cambridge

Chang Ha-Joon, 1994, *The Polictical Economy of Industrial Policy*, MacMillan, London

Chang, Sei-Myung, 1998, “The Semiconductor Technological Systems in Korea and Taiwan: What Explains Catching-Up?”, paper presented at the DRUID Winter Conference, Danish Research Unit for Industrial Dynamics, January 8-10

Dahlman, C., B. Ross-Larson, and L. Westphal [1987], "Managing Technological Development: Lessons from the Newly Industrialising Countries", *World Development*, Vol. 15/6

Dalum, Bent, Keld Laursen and Gerd Villumsen, 1998, “Is there such a thing as a good specialization pattern?”, paper presented at the DRUID Winter Conference, Danish Research Unit for Industrial Dynamics, January 8-10

Dataquest annual report, San José,CA, various years

Dore, R. (1973), *British Factory-Japanese Factory*, University of California Press, Berkeley

Dosi, G.; C. Freeman; R. Nelson; G. Silverberg and L. Soete (eds.), *Technical Change and Economic Theory*, Pinter Publishers, London

Ernst, D., 1998a, “Externalization and inter-organizational networks. How globalization transforms the Japanese model”, in: Daniel Dirks (ed.), *Between External Shocks and Internal Evolution: Towards a New Phase in Japanese Management Practices* , Springer Verlag, Berlin and New York

Ernst, D., 1998b, “What Permits David to Defeat Goliath? Inter-Organizational Knowledge Creation in the Taiwanese Computer Industry”, paper prepared for the Asia-Pacific Journal of Management Conference on Knowledge Creation Strategies in Asia (Guest editor: Ikujiro Nonaka), Singapore, March 1998 . An earlier version has been published as Danish Research Unit for Industrial Dynamics *(DRUID) Working Paper # 98-3, February*

Ernst, D.,1998c, *Globalization and Local Capabilities: Does Knowledge Migrate Within International Production Networks?*, Copenhagen Business School Press, Copenhagen (forthcoming)

Ernst, D., 1997 a, “Partners in the China Circle? The Asian Production Networks of Japanese Electronics Firms”, in: Barry Naughton (ed.), *The China Circle*, The Brookings Institution Press, Washington, D.C. .

Ernst, D., 1997b, “High-Tech Competition Puzzles. How Globalization Affects Firm Behavior and Market Structure in the Electronics Industry”, Danish Research Unit for Industrial Dynamics *(DRUID) Working Paper # 97-10, September*

Ernst, D. 1997 c, *From Partial to Systemic Globalization. International Production Networks in the Electronics Industry*, report prepared for the Sloan Foundation project on the Globalization in the Data Storage Industry, Graduate School of

International Relations and Pacific Studies, University of California at San Diego, jointly published as *The Data Storage Industry Globalization Project Report 97-02*, Graduate School of International Relations and Pacific Studies, University of California at San Diego, and *BRIE Working Paper # 98*, the Berkeley Roundtable on the International Economy (BRIE), University of California at Berkeley, April 1997. (94 pages)

Ernst, D. 1994a , "Network Transactions, Market Structure and Technological Diffusion - Implications for South-South Cooperation", in: L. Mytelka (ed.), *South-South Cooperation in a Global Perspective*, Development Centre Documents, OECD, Paris

Ernst, D., 1994b, *What are the Limits to the Korean Model? The Korean Electronics Industry Under Pressure*, A BRIE Research Monograph, The Berkeley Roundtable on the International Economy, University of California at Berkeley, Berkeley , 129 pages

Ernst, D. [1987], " U.S.-Japanese Competition and the Worldwide Restructuring of the Electronics Industry - A European View", in: J. Henderson and M. Castells (eds.), *Global Restructuring and Territorial Development*, Sage Publications, London

Ernst, D. [1983], *The Global Race in Microelectronics*, with a foreword by David Noble, MIT, Campus, Frankfurt and New York

Ernst, Dieter and Paolo Guerrieri, 1998, "International Production Networks and Changing Trade Patterns in East Asia. The Case of the Electronics Industry", *Oxford Development Studies*

Ernst, D., L. Mytelka and T. Ganiatsos, 1998, "Export Performance and Technological Capabilities - A Conceptual Framework", chapter I in: Ernst, Ganiatsos and Mytelka (eds.), *Technological Capabilities and Export Success - Lessons from East Asia*, Routledge Press, London etc.

Ernst, Dieter and Bengt-Åke Lundvall, 1998, "Information Technology in The Learning Economy - Challenges for Developing Countries" in: Erich Reinert (editor), *Evolutionary Economics and Spatial Income Inequality* , Edward Elgar Press, London

Ernst, Dieter and John Ravenhill, 1998, "Globalization, Convergence, and the Transformation of International Production Networks in Electronics in East Asia", paper prepared for the XVII World Congress of the International Political Science Association (IPSA), Seoul, August 17 to 21, submitted to: *California Management Review*

Ernst, D. and O'Connor, D. [1992], *Competing in the Electronics Industry. The Experience of Newly Industrialising Economies*, Development Centre Studies, OECD, Paris, 303 pages

Ernst, Dieter and David O'Connor [1989], *Technology and Global Competition. The Challenge for Newly Industrialising Economies*, OECD Development Centre Studies, Paris, 149 pages

Evans, P., 1995, *Embedded Autonomy. States and Industrial Transformation*, Princeton University Press, Princeton, New Jersey

Fields, K.J., 1995, *Enterprise and the State in Korea and Taiwan*, Cornell University Press, Ithaca, N.Y.

Frankel, J.; S. Phillips and M. Chinn, 1992, "Financial and Currency Integration in the European Monetary System: The Statistical Record", Working Paper 1.3, Center for German and European Studies, University of California at Berkeley, March

Freeman, C. (1982), *Economics of Industrial Innovation*, Frances, Pinter, London

Frieden, J.A.,1991, “Invested Interests: The Politics of National Economic Policies in a World of Global Finance”, *International Organization*, Vol. 45, #4

Fruin, W. M. (1997), *Knowledge Works. Managing Intellectual Capital at Toshiba*, Oxford University Press, New York and Oxford

Fruin, M, 1992, *The Japanese Enterprise System - Competitive Strategies and Cooperative Structures*, Clarendon Press, London

Gee, San and Wen-Jeng Kuo [1994], "Taiwan's Export Success and Technological Capabilities: The Case of Textiles and Electronics", in: Ernst, D. ; T. Ganiatsos and L. Mytelka (eds.), *Technological Capabilities and Export Success - Lessons from East Asia*, Routledge, London

Gerlach, M.L., 1993, *Alliance Capitalism - The Social Organization of Japanese Business*, University of California Press, Berkeley

Gerschenkron, A. (1962), *Economic Backwardness in Historical Perspective. A Book of Essays*, Belknap Press of Harvard University Press, Cambridge, Mass

Graham, E.M. [1994], "Financial Liberalization and the Environment for U.S. Investment - A Private U.S. Perspective", in: *Korea's Economy 1994*, Vol. 10, Korea Economic Institute of America, Washington, D.C.

Granstrand, O. (ed.) (1992), *Technology Management and International Business: Internationalization of R&D and Technology*, Wiley, New York

Gu, Shulin, 1996, “Toward an Analytical Framework for National Innovation Systems”, *INTECH Working Paper #9605*, Institute for New Technologies, The United Nations University, Maastricht, Netherlands

Guerrieri, P. (1991), "Technology and International Trade Performance of the Most Advanced Countries", *BRIE Working Papers*, The Berkeley Roundtable on the International Economy, University of California at Berkeley

Haggard, 1990, *Pathways from the Periphery: The Politics of Growth in the Newly Industrializing Countries*, Cornell University Press, Ithaca, New York

Hikino, T. and A. Amsden, 1992, “Staying Behind, Stumbling Back, Sneaking Up, Soaring Ahead: Late Industrialization in Historical Perspective”, in: W.J. Baumol et al (eds), *International Convergence of Productivity, With Some Evidence from History*, Oxford University, New York and Oxford

Imai, K.I. and Y. Baba [1991], "Systemic Innovation and Cross-Border Networks. Transcending Markets and Hierarchies to Create a New Techno- Economic System", in: OECD, *Technology and Productivity: The Challenge for Economic Policy*, Paris

Inoue, Ryuichiro, 1993, “An East Asian Industrial Policy Model”, in: R. Inoue, H. Kohama and S. Urata (eds.), *Industrial Policy in East Asia*, JETRO, Tokyo, Japan

Janelli, R., L. and Dawnhee Yim [1993], *Making Capitalism. The Social and Cultural Construction of a South Korean Conglomerate*, Stanford University Press, Stanford,CA

Johnson, Ch., (1987), “Political Institutions and Economic Performance: The Government-Business Relationship in Japan, South Korea and Taiwan, in: F.C.Deyo (ed.), *The Political Economy of the New Asian Industrialization*, Cornell University Press, Ithaca, New York

Jomo, K.S., 1998, “Financial Liberalization, Crises, and Malaysian Policy Responses”, paper presented at the *Nordic Research Seminar on the Economic Crisis in East and Southeast Asia*, Centre for Development and the Environment (SUM), University of Oslo, Oslo, January 23-24

Jun, Yong-Wook and Sang-Gook Kim [1990], *Structure and Strategy in the Korean Electronics Industry*, report prepared for the OECD Development Centre, OECD, Paris

Kenney, M. and R. Florida (1992), *Beyond Mass Production: The Japanese System and its Transfer to the U.S.*, Oxford University Press, New York and Oxford

Kim Hwan Suk [1991], " Ideology of Science and Technology and the Korean Society", in: Korean Industrial Research Society (ed.), *Korean Society and its Dominant Ideologies*, Seoul

Kim Hwan Suk [1993], "Technological Innovation and Industrial Relations", paper presented at a Korean Industrial Relations Society Conference, Seoul

Kim Ilyong and Chiyong Kim [1991], "Comparison of Korean to Western R&D - Project Selection Factors for New Product Development", mimeo, Science and Technology Policy Institute, Korea Advanced Institute of Science and Technology (KAIST), Seoul

Kim, Ilyong and Sunyang Chung [1991], " R&D Cooperation Between Large Manufacturing Companies and Suppliers", mimeo, Science and Technology Policy Institute, Korea Advanced Institute of Science and Technology (KAIST), Seoul

Kim, J. I., and Lau, L.J. (1994) "The Sources of Economic Growth in the East Asian Newly Industrialized Countries", *Journal of Japanese and International Economics*, April

Kim, Linsu, 1997 a, *Imitation to Innovation. The Dynamics of Korea´s Technological Learning*, Harvard Business School Press, Boston, Mass.

Kim, Linsu , 1997b, “Korea´s National Innovation System in Transition”, paper presented at international symposium on “Innovation and Competitiveness in Newly Industrializing Economies”, Science & Technology Policy Institute, Seoul, Korea, May 26-27.

Kim Linsu [1993], " The Structure and Workings of the National Innovation System in Korea", paper presented at the conference on "Redefining Korean Competitiveness in an Age of Globalization", Center for Korean Studies, University of California at Berkeley

Kim Linsu, 1992 , “ National System of Industrial Innovation: Dynamics of Capability Building in Korea”, in: Richard Nelson (ed.), *National Innovation Systems: A Comparative Analysis*, Oxford University Press, New York and Oxford

Kim Pyung Joo, 1994, “Financial Institutions”, in: Lee-Jay Cho and Yoon Hyung Kim (ed.s), *Korea´s Political Economy. An Institutional Perspective*, Westview Press, Boulder etc.

Kim S. Ran, 1996, “The Korean system of innovation and the growth dynamics of the semiconductor industry: politics and governance”, manuscript, SPRU, University of Sussex, August

Kim, Sun G, 1995, “S&T Promotion Policy and the Incentive Scheme for Technological Capability Building in Korea: Facts and Characteristics”, in: STEPI, *Review of Science and Technology Policy for Industrial Competitiveness in Korea*, Science & Technology Policy Institute, Seoul, Korea

Kogut, B. and E. Zander [1993], " Knowledge of the Firm and the Evolutionary Theory of the Multinational Corporation", *Journal of International Business Studies*, Vol.24, No.4

Kohama, H. and S. Urata, 1993, “Protection and Promotion of Japan`s Electronics Industry”, in: Inoue, Ryuichiro et al (eds.), *Industrial Policy in East Asia*, JETRO, Tokyo

Krugman, Paul, 1998, “What happened to Asia?”, available on-line at http: //web.mit.edu/krugman/www/DISINTER.html, January.
Krugman, P., (1994), "The Myth of Asia's Miracle" , *Foreign Affairs*, December
Kwon Okyu [1994], "Financial Liberalization and the Environment for U.S. Investment", in: *Korea's Economy 1994*, Korea Economic Institute of America, Washington, D.C.
Lall, S., 1997, “Technological Change and Industrialization in the Asian NIEs: Achievements and Challenges”, paper presented at international symposium on “Innovation and Competitiveness in Newly Industrializing Economies”, Science & Technology Policy Institute, Seoul, Korea, May 26-27.
Langlois, R.N., 1992, “External Economies and Economic Progress: The Case of the Microcomputer Industry”, *Business History Review*,#66, spring 1992
Langlois, Richard N. and Paul L. Robertson, 1995, *Firms, Markets and Economic Change: A Dynamic Theory of Business Institutions*, Routledge, London
Langlois, Richard N. and W. Edward Steinmueller, 1997, “The Evolution of Competitive Advantage in the Global Semiconductor Industry: 1947-1996”, paper presented to the DRUID seminar on Industrial Dynamics and Competition, June, Skagen, Denmark
Lee, Jin-Joo [1992], "The Status and Issue of Management Dynamism and Four Case Studies in the Republic of Korea", in: Asian Productivity Organization(APO), *Management Dynamism. A Study of Selected Companies in Asia*, APO, Tokyo
Lee, Suk-Chae ,1991, “The Heavy and Chemical Industry Promotion Plan”, in: Lee-Jay Cho and Yoon Hyung Kim (eds.), *Economic Development in the Republic of Korea. A Policy Perspective*, East-West Center, University of Hawaii Press
Lee Won-Young (1995), “Building Scientific and Technological Infrastructure”, manuscript, Science & Technology Policy Institute, Seoul, Korea
Linden, Hart and Lenway (1997), “Advanced Displays in Korea and Taiwan”, report for the Alfred P. Sloan Foundation, BRIE, UC Berkeley
Lundvall, B.-Å. (1996), “The Social Dimension of the Learning Economy”, *DRUID Working Paper, No 1, April*, Department of Business Studies, Aalborg University.
Lundvall, B.-Å (1995), “The Learning Economy - Challenges to Economic Theory and Policy”, paper presented at EAEPE-Conference in Copenhagen 27-29 October 1994.,
Lundvall, B.A., (ed.), 1992, *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, Pinter Publishers, London
Lundvall, B.-Å and Johnson, B. (1994), 'The learning economy', *Journal of Industry Studies*, Vol. 1, No. 2, December 1994, pp. 23-42.
McMillan, C.J., (1985), *The Japanese Industrial System*, Walter de Gruyter, Berlin etc.
Mody, A., 1989, “Institutions and Dynamic Comparative Advantage: Electronics Industry in South Korea and Taiwan”, Industry and Energy Department *Working Paper # 9*, World Bank, Wahsington, D.C.
Mowery, D., 1993, “Inward Technology Transfer and Competitiveness: The Role of National Innovation Systems”, paper presented at the UNU-INTECH conference on National Innovation Systems, Maastricht, Netherlands
Nelson, R. (ed.), 1992, *National Innovation Systems*, Oxford University Press, London etc.

Nelson, R. and H. Pack, 1995, “The Asian growth miracle and modern growth theory”, manuscript, School of International and Public Affairs, Columbia University, December

Nelson, R. and S. G. Winter, 1982, *An Evolutionary Theory of Economic Change*, Bellknap Press, Cambridge:Mass

Nilsson, J.E., 1996, “Introduction: the internationalization process”, in: J.E.Nilsson, P. Dicken and J. Peck (eds.), *The Internationalization Process. European Firms in Global Competition*,, Paul Chapman Publishing Ltd., London

Nishiguchi, Toshihiro (1994), *Strategic Industrial Sourcing. The Japanese Advantage*, Oxford University Press, New York and Oxford

Nonaka, I. and H. Takeuchi (1995), *The Knowledge Creating Company*, Oxford University Press, Oxford.

Odagiri, H. and A. Goto (1992), "The Japanese System of Innovation: Past, Present and Future", in: Nelson, R. (ed.), 1992, *National Innovation Systems*, Oxford University Press, London etc.

OECD (1996a), *Science, Technology and Industry Outlook 1996*, Paris,

OECD (1996b), *Growth and Employment in the Knowledge-based Economy*, Paris

OECD (1996c), *Transitions to Learning Economies and Societies*, Paris

OECD , 1995a, *Reviews of National Science and Technology Policy: Korea. Part I: Background Report*, DSTI/STP(95) 16, OECD, Paris

OECD, 1995b, *Reviews of National Science and Technology Policy: Korea. Part II: Examiners´ Report*, DSTI/STP (95)15, OECD, Paris

OECD, 1992a, *Technology and the Economy. The Key Relationships*, Paris

OECD, 1992b, *Industrial Policy in OECD Countries: Annual Review*, Paris

Oki, Toshie, 1993, “Technology Development in South Korea”, *RIM. Pacific Business and Industries*, Vol.III, Center for Pacific Business Studies, Sakura Institute of Research, Tokyo

Office of Technology Assessment (OTA), 1991, *Competing Economies: America, Europe, and the Pacific Rim*, Congress of the United States, Washington, D.C.

Patrick, H.T. and Yung Chul Park (eds.), *The Financial Development of Japan, Korea and Taiwan*, Oxford University Press, New York and Oxford

Pavitt, Keith,1984, “Sectoral patterns of technical change: Towards a taxonomy and a theory”, *Research Policy*, Vol.13;

Ranis, G., 1998, “ Miracles that don´t cease”, *Financial Times*, February 19, 1998, p.12

Richardson, G.B., 1996, “ Competition, Innovation and Increasing Returns”, , *DRUID Working Paper #96-10*, Danish Research Unit for Industrial Dynamics (DRUID), Department of Business Studies, Aalborg University, July

Roberts, P.C., 1997, “The Asian Crisis Proves Industrial Policy Doesn´t Pay”, *Business Week*, December 22, p.12.

Sabel, C. et al [1991], "Kooperative Produkion. Neue Formen der Zusammenarbeit zwischen Endfertigern und Zulieferern", in: H.G. Mendius et al (eds.), *Zulieferer im Netz*, Bund Verlag, Koeln (Cologne)

Sachs, Jeffrey (1997), “The Wrong Medicine for Asia”, *New York Times*, November 3

San Gee (1995), *Technology Support Institutions and Policy Priorities for Industrial Development in Taiwan, R.O.C.*, report prepared for the Ministry of Economic Affairs, Taipei, Taiwan

San Gee and Wen-jeng Kuo (1998), " Export Success and Technological Capability: Textiles and Electronics in Taiwan", chapter II in: Ernst, D. ; T. Ganiatsos and L. Mytelka (eds.), *Technological Capabilities and Export Success - Lessons from East Asia*, Routledge Press, London etc.

Schive, Chi, 1993, "Industrial Policies in a Maturing Taiwan Economy", Council for Economic Planning and Development, Taipei , Taiwan

Schumpeter, J., 1912, *Theorie der wirtschaftlichen Entwicklung*, Leipzig

Scitovsky, T.,1986, "Economic development in Taiwan and South Korea, 1965-1981", in: L. Lau (ed.), *Models of Development: A Comparative Study of Economic Growth in South Korea and Taiwan*, Institute for Contemporary Studies, San Francisco

Stiglitz, Joseph, 1997, "How to Fix the Asian Economies", *New York Times*, October 31,

UNCTAD, 1995, *World Investment Report 1995. Transnational Corporations and Competitiveness*, United Nations, New York and Geneva

Veneroso, F. and R. Wade, "The Asian Financial Crisis: The Unrecognized Risk of the IMF`s Asia Package", paper presented at the *Nordic Research Seminar on the Economic Crisis in East and Southeast Asia*, Centre for Development and the Environment (SUM), University of Oslo, Oslo, January 23-24

Wade, R., 1990, *Governing the Market: Economic Theory and the Role of Government in East Asian Industrialization*, Princeton University Press, Princeton

Wong Poh Kam, 1991, *Technological Development through Subcontracting Linkages*, Asia Productivity Organization (APO), Tokyo

World Bank, 1984, *Korea´s Development in a Global Context*, World Bank, Washington, D.C.

Yoo, Jung Ho, 1990, " The Industrial Policy of the 1970s and the Evolution of the Manufacturing Sector in Korea", *Working Paper # 9017*, Korea Development Institute, Seoul

Young, A., 1993 "The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Enterprise", *Sloan School of Management*, MIT, Cambridge, Mass., July

Danish **R**esearch **U**nit for **I**ndustrial **D**ynamics

The Research Programme

The DRUID-research programme is organised in 3 different research themes:

- The firm as a learning organisation

- Competence building and inter-firm dynamics

- The learning economy and the competitiveness of systems of innovation

In each of the three areas there is one strategic theoretical and one central empirical and policy oriented orientation.

Theme A: The firm as a learning organisation

The theoretical perspective confronts and combines the ressource-based view (Penrose, 1959) with recent approaches where the focus is on learning and the dynamic capabilities of the firm (Dosi, Teece and Winter, 1992). The aim of this theoretical work is to develop an analytical understanding of the firm as a learning organisation.

The empirical and policy issues relate to the nexus technology, productivity, organisational change and human ressources. More insight in the dynamic interplay between these factors at the level of the firm is crucial to understand international differences in performance at the macro level in terms of economic growth and employment.

Theme B: Competence building and inter-firm dynamics

The theoretical perspective relates to the dynamics of the inter-firm division of labour and the formation of network relationships between firms. An attempt will be made to develop evolutionary models with Schumpeterian innovations as the motor driving a Marshallian evolution of the division of labour.

The empirical and policy issues relate the formation of knowledge-intensive regional and sectoral networks of firms to competitiveness and structural change. Data on the structure of production will be combined with indicators of knowledge and learning. IO-matrixes which include flows of knowledge and new technologies will be developed and supplemented by data from case-studies and questionnaires.

Theme C: The learning economy and the competitiveness of systems of innovation.

The third theme aims at a stronger conceptual and theoretical base for new concepts such as 'systems of innovation' and 'the learning economy' and to link these concepts to the ecological dimension. The focus is on the interaction between institutional and technical change in a specified geographical space. An attempt will be made to synthesise theories of economic development emphasising the role of science based-sectors with those emphasising learning-by-producing and the growing knowledge-intensity of all economic activities.

The main empirical and policy issues are related to changes in the local dimensions of innovation and learning. What remains of the relative autonomy of national systems of innovation? Is there a tendency towards convergence or divergence in the specialisation in trade, production, innovation and in the knowledge base itself when we compare regions and nations?

The Ph.D.-programme

There are at present more than 10 Ph.D.-students working in close connection to the DRUID research programme. DRUID organises regularly specific Ph.D-activities such as workshops, seminars and courses, often in a co-operation with other Danish or international institutes. Also important is the role of DRUID as an environment which stimulates the Ph.D.-students to become creative and effective. This involves several elements:

- access to the international network in the form of visiting fellows and visits at the sister institutions
- participation in research projects
- access to supervision of theses
- access to databases

Each year DRUID welcomes a limited number of foreign Ph.D.-students who wants to work on subjects and project close to the core of the DRUID-research programme.

External projects

DRUID-members are involved in projects with external support. One major project which covers several of the elements of the research programme is DISKO; a comparative analysis of the Danish Innovation System; and there are several projects involving international co-operation within EU's 4th Framework Programme. DRUID is open to host other projects as far as they fall within its research profile. Special attention is given to the communication of research results from such projects to a wide set of social actors and policy makers.

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