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S. Ran Kim
August 1996

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1. Introduction

The semiconductor industry represents one of the most dramatic cases of success that the newly industrialising country, Korea, has achieved. Korean firms like Samsung have been able to catch up and move to the frontier in a narrow range of products of this technology-intensive industry within a very short time, now becoming major global players in the world DRAM market. At the same time, the quality of the Korean national system of innovation was and is relatively poor, in terms of both its major components and its interactive quality.

In dealing with this apparently intriguing phenomenon, we shall here try to explain the growth dynamics of the Korean semiconductor industry. This will be undertaken primarily by using the concept of sectoral governance. We shall reconstruct the *historically evolving* interactions of state, market and firm, and identify the changing pattern of sectoral governance, its causes, and its consequences for the development process of the Korean semiconductor industry by examining the *ways* in which the three critical variables of state, market and firm have interacted and combined to produce the present performance of the Korean semiconductor industry, we shall aim to move beyond the *state vs. market dualism* which has dominated the literature on Korean/East Asian industrialisation. In this way, we intend to provide some sophisticated insights into the growth dynamics of the Korean semiconductor industry.

Methodologically, we aim at a historically well-grounded analysis of the largely *path-dependent* development process of the Korean semiconductor industry. We shall therefore inquire into the specific conditions in which state actions, market dynamics and firm strategies have combined to advance the growth and development of the semiconductor industry in Korea. The starting conditions, the specific dynamics, as well as the final outcomes of the development process of the Korean semiconductor industry will be sketched. We consider this kind of mapping exercise of the interplay of state, market and firm as essential for a proper understanding of the Korean semiconductor development process. This is also necessary to avoid any ill-judged emulation efforts by other countries of the Korean success in semiconductors.

In this paper, we shall argue that the current success of the Korean semiconductor industry is the product neither of a Korea, Inc. approach nor of the dynamics of the free world market. We shall show that the Korean success in semiconductors involved much more *complex* and *unorthodox* interactions between state actions and market dynamics than the proponents of the state or market regulation views on Korean industrialisation normally suggest.[1] Our evidence shows that the Korean semiconductor success is rather the result of the complex interactions between regulations underpinning the world market (in particular, the US-Japan semiconductor trade agreements), the largely corporatist state in Korea, and the *chaebol* (with their particular structural strengths for effectively mobilising and coordinating the necessary actors and resources at the group level).

[1] See for the market regulation view, Balassa (1981) and various publications of the World Bank on the Korean industrialisation. See for the state regulation view, Wade and White (1984) and Deyo (1987).

It follows from this revised view that Korean firms became particularly successful in the Dynamic Random Access Memory (DRAM) segment, largely because of the distinctive pattern of *chaebol*-governance which has evolved out of the historical interactions of state, market and firms in the 1980s. In particular, Korea's national institutional arrangements, such as the state-firm relationship based upon *reciprocal subsidy*, have been conducive to the emergence of effective *chaebol*-governance, which matches very well with the specific technological and economic conditions of competiton in the DRAM segment.The paper argues that the main challenge lies ahead. It remains doubtful whether this institutional structure (with its rather impoverished domestic regime of governance) will perform well in the different product segments into which Korean firms want to diversify, or even in the face of the changed competitive requirements within the DRAM segment itself.

This paper is structured as follows. Section 2 provides some information on the actual scale and profile of the Korean success in semiconductors, which is almost entirely based upon DRAMs and is thus highly unbalanced. It also discusses the problems that follow from one-sided success based on DRAMS. Section 3 presents the conceptual and analytical framework for the study of the growth dynamics of the Korean semiconductor industry; this serves to explain the Korean DRAM success despite the general weakness of the national system of innovation. Section 4 is the empirical core of the paper, and contains a detailed analysis of the historical evolution of the sectoral governance structure and development process of Korean semiconductor industry. Section 5 sums up the empirical findings and provides some tentative arguments as to the future development of Korean semiconductor industry. It also identifies the individual role played by the state, firm, and market in the Korean semiconductor development process. Section 6 draws broader conclusions for theory and the scope for generalising from the Korean semiconductor model.

In essence, we argue that the concept of a 'national system' of innovation, albeit useful for analysing systematically the national context of firms' competitiveness, should be sharpened on taking more explicit account of the distinctive socio-political processes which underlie each national system of innovation.

2. Korea's rise as a DRAM production centre

Korea has become an important global player in the semiconductor industry. Most impressive of all is Samsung's emergence as the seventh biggest chip producer in the world by 1993 and the world market leader in MOS memory chips and its DRAM segment. Samsung managed to achieve this performance within a very short time. Its market share in memory chips in 1984 was virtually zero, but by 1986 it had already increased to 1.4% and by 1988 to 5.6%, before obtaining 10.2% of the world market share by 1993 (Bae, Y.H. 1995).

In 1994, Samsung was once again the world's biggest producer of 1M DRAMs and 4M DRAMs, attaining a 13% market share for both (ICE 1995, 6-99f). It had become one of the first producers of 16M DRAMs to use mass production techniques, and has achieved the best yield rates so far in these advanced chips (KSIA 1995b). The other two Korean semiconductor firms, Goldstar and Hyundai, are also very successful in the world DRAM market. Goldstar and Hyundai had attained the 20th and 21st places in the world semiconductor market by 1994, and the sixth and seventh places in the DRAM segment in particular. Goldstar and Hyundai are also among the first mass-producers of 16M DRAMs (Samsung 1995).[2]

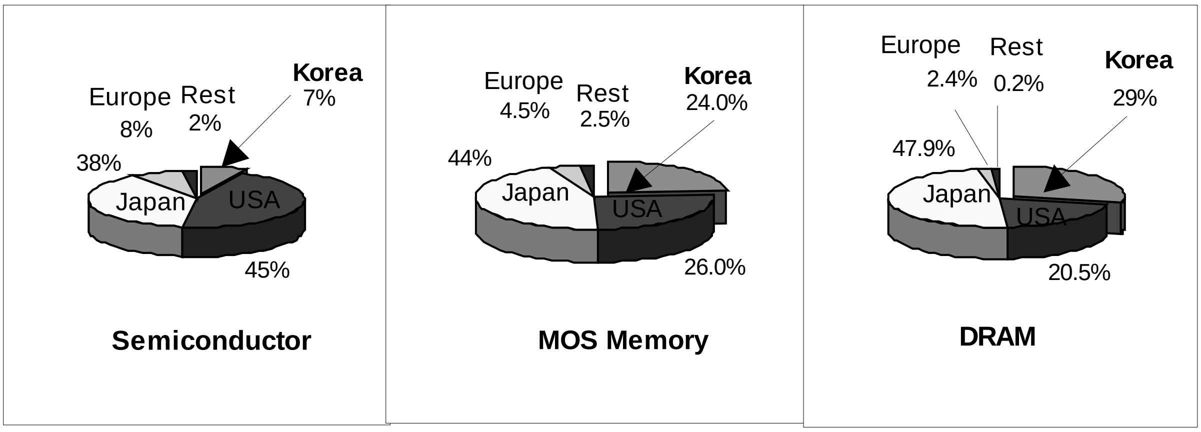
Thanks to such strength in DRAMs, Korea could achieve 7% of the world market share in total semiconductors - in 1994, it occupied third place in the world ranking, just after the USA and Japan. Figure 1 shows a breakdown of the Korean semiconductor production according to the product segment. It shows that the Korean chip-makers owe their impressive success almost entirely to their performance in MOS (Metall Oxide Semiconductor) memory chips and its DRAM segment.

The three Korean chip producers together are likely to achieve 39% of the world market share in DRAMs by 1998 and thus to overtake Japan, whose market share is predicted to be 37% by that year (*Seoul Kyungje* Newspaper, 3 July 1995). The data and prognoses thus clearly show Korea's ascent to becoming a DRAM production centre of the world.

However, the drawback to such an impressive performance in DRAMs is the extremely weak competitive position of the Korean semiconductor industry in other important semiconductor products (EIAK 1994, 110), which presents a dilemma for the following reasons:

[2] Thanks to the persisting demand for 4M DRAMs and 16M DRAMs, and even for 1M DRAMs, for PC computers and multimedia, Korean companies achieved a record profit level in 1994. Their profit margin amounted to as much as 30% in 1994 (*Financial Times*, 29 August 1994). DRAMs represent the biggest revenue source for Korean chip makers. 86.8% of Samsung's entire semiconductor earnings in 1995 originated from the sale of memory chips. In the case of Goldstar, the percentage was even higher at 89.8% (see Dataquest 1995). According to KSIA (1993), in the case of Hyundai, the share in 1993 may have been as much as 95%.

Figure 1: Market share of the Korean semiconductor industry in the world semiconductor industry, in MOS memory chips and the DRAM segment



Source: Electronics Industry Association of Korea (1995)

1) DRAMs make up less than 30% of the world's total semiconductor demand. In the other important semiconductor markets, like ASICs or microprocessors, which thus make up more than 70% of the entire semiconductor demand, Korean producers are hardly visible (*Dataquest* 1995). When comparing the world's demand structure for semiconductors with the Korean semiconductor production structure, the lack of correspondence between the two stands out clearly. Figure 2 shows that the share of MOS memory chips in total Korean chip production was 84.7% in 1993, whereas their share in the world market amounted to only 27.5%.

Figure 2: World-wide Demand for Chips in Comparison with Korean Production

World-wide Demand Structure	**Korean Chip Production Structure**
MOS Memory 27.5%	MOS Memory 84.7%
Micro Logic 40.0%	Micro/Logic 4.8%
Linear IC 18.0% Discrete 4.5%	Linear IC 6.0% Discrete 4.5%

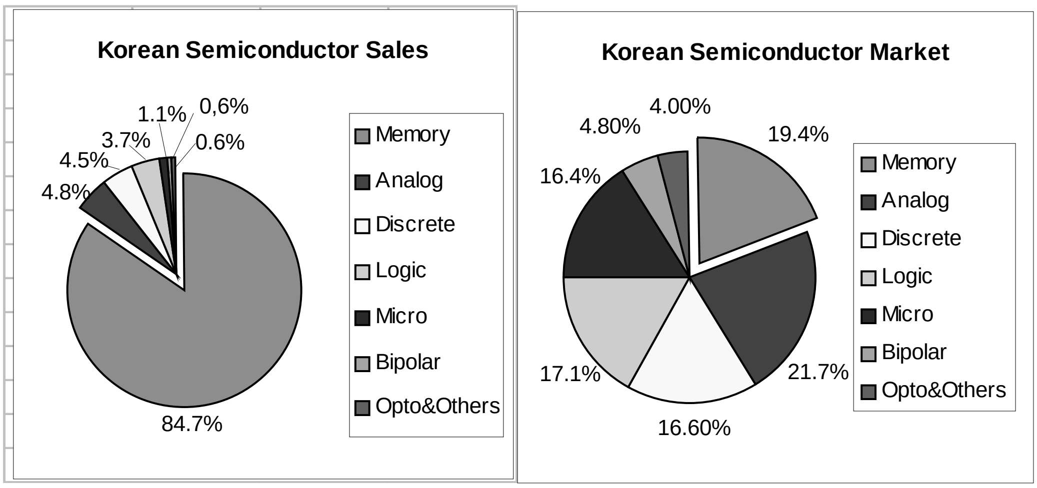
Source: World Semiconductor Trade Statistics and Korean Industrial Association of Semiconductor Manufacturers quoted in Ju/Park (1995)

Moreover, the present share of memory chips in total world demand for semiconductor is predicted to decrease constantly (e.g. from 26% in 1993 to 23.5% in 1997), while a high growth potential for non-memory chips is expected in the future: recent predictions are of a rise from 74% in 1993 to 76% in 1995 and then to 76.5% in 1997 (*Dataquest* 1993/10, quoted in Samsung 1994).

2) The one-sided DRAM-orientation of the Korean semiconductor industry appears to be far too risky, owing to the highly cyclical nature of the market for DRAMs. Thus the dilemma facing the Korean semiconductor producers is one of how to progress beyond memory chips, while still sustaining their DRAM strength, as Samsung's CEO, Lee Kun-Hee acknowledged as follows: "It's too risky to depend on a single product like DRAMs . . . Our problem is to progress beyond memory without sacrificing our strength in memory" (*Electronics business buyer*, 18 February 1994).

3) Another serious problem is the absence of technological synergy, an inevitable consequence of the one-sidedly DRAM-oriented production structure of the Korean semiconductor industry. The demand and production structures of the Korean semiconductor industry diverge far too much from each other. This is clearly recognisable from comparing the composition of the ICs produced and used in Korea (see Figure 3).

Figure 3: Korean Semiconductor Sales and the Korean Semiconductor Market (in 1993)



Source: KSIA (1994a)

While memory chips make up 84.7% of total Korean semiconductor production, their share in total Korean demand for chips comes to only 19.4%. The diverging demand and production structure of chips in Korea would thus lead eventually to a loss of important innovation sources, such as learning-by-interaction between the semiconductor and its user industries and of the potential technological synergy effects. The latter are likely to be significant, not only in connection with the traditional user industries like consumer electronics, but also with regard to newly emerging industries like multimedia.

Korean chip producers are either vertically integrated electronics companies (Hyundai and Samsung) or at least a member company of an electronics conglomerate (Goldstar; recently renamed LG). They are thus also present and active in the downstream industries of consumer electronics, computer and telecommunication industries. However, despite their simultaneous activities in the semiconductor industry, the Korean firms are not able to benefit significantly from guaranteed in-house consumption, nor are they in a position to reap the benefits arising from their chip strength in the downstream market. So, for example, the share of Samsung's in-house sales of its chips amounts to no more than 7.5% in 1995 (interview with SEC, 1995). In the case of Goldstar also, the percentage of in-house sales is less than 10% of its entire chip production (interview with LG Semicon).

The majority of the DRAMs produced in Korea are exported to foreign countries and the other non-memory chips required, like microprocessors, are imported from other countries. The extremely high import- and export-dependence ratio of the Korean semiconductor industry is therefore both the cause and the consequence of the extremely imbalanced, DRAM-oriented production structure (*Chosawolbo*, 1993/6).

The semiconductor production totalled US $8,508 million in 1994, and 90% of this was exported. For 1995, an export ratio of 91% was predicted. Despite the constantly decreasing imports, the import ratio of 76% still remains high, and was not expected to fall below 69% in 1995 (KSIA 1995a, 30).

The unduly strong focus on DRAMs and the lack of orientation to user needs have led to a fragmentation of the Korean semiconductor industry. The problem of a fragmented industrial structure is even becoming compounded, through the poor development of industries for semiconductor production machinery and materials. Despite this fragile industrial structure, Korean DRAM producers have so far successfully competed in the world market, mainly on the basis of process innovation and manufacturing efficiency, which have resulted in a high yield rate (see for details: Ju/Park 1995, KSIA 1995a; NRI 1993; Kim, S.R. forthcoming).

3. Explaining Korea's DRAM success: conceptual and analytical framework

Although there are still many structural conditions on the supply side to be fulfilled if the growth dynamics of the Korean semiconductor industry are to be sustained over longer periods, the performance of the Korean semiconductor industry is nonetheless a very impressive one.

At the same time, the quality of the Korean national system of innovation is relatively poor, compared with some in developed countries in terms both of its major components and of its interactive quality.[3] According to recent research into broad features of the national system of innovation in Korea, its essential ingredients are not very well advanced (Ernst/O'Conner 1992; Kim, L.S. 1993; Kim, H.S. *et al.* 1992). For example, the public R&D institutions and the higher educational system, both of which are quite poorly developed, are among the most significant limitations of the Korean national system.[4]
Korea is also a case of very limited interactivity, where the state-*chaebol* nexus is strong, but the inter-firm networks between large system producers and small and medium-sized suppliers are still poorly developed (Kim, S.R. 1993). This is particularly true in the case of technology networks between the large electronics manufacturing companies and suppliers of parts and components (Ernst/O'Conner 1992).

The question then arises of how this remarkable achievement has been made possible in such a highly challenging and sophisticated industry (where complex technological and marketing skills are essential for competitiveness), despite such a *general* weakness of the national system of innovation? To date, authors on national systems of innovation have merely pointed out that the national context matters more in some cases or sectors than in others for industrial performance (Nelson/Rosenberg 1993). To analyse this more adequately, we have to look more closely at the links between the former and the latter.

This is an important field of enquiry, because even the apparently most successful country is not successful in all sectors. Countries are frequently successful only in certain sectors or even in some limited segments within a sector, as shown by Korea's success being so far limited to the DRAM segment. And their 'absolute competitive advantages' (OECD 1992) are not evenly distributed across sectors. So, in this paper, we address the *sectoral contingency* of Korea's development success.

The view advanced here is that the success of a country in a particular sector is to be explained through the combination of specific technological and economic characteristics of the relevant sector and the political-institutional variables of the country in question. To analyse how the distinctive characteristics of the Korean national system of innovation (together with or because of its underlying socio-political forces) have been concretely translated into Korea's successful performance in the DRAMs of the semiconductor industry, we shall draw, first of all, upon the existing conceptual tool of *governance*. Governance refers to the process of co-ordination and regulation of transactions: it is best conceptualised at the level of industries and industrial sectors (Campbell *et al.* 1991). The governance structure matters for the performance of a sector,

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[3] See for the definition of the national system of innovation Freeman (1987, 1), and see Freeman (1991, 26) for its importance for innovation and competitive performance.

[4] Korea also lags very much behind other countries in patents and publications. See for details *Nature*, July 1993, Vol. 364, p.379.

as 'the different governance modes conduce to a different mix of co-operation and competition' (Sako 1994: 19).

The normative interest behind governance is then about finding an *optimal mix of co-operation and competition* within a specific sector. Such a complex governance mode is often needed because of the limits of market and hierarchical governance modes in isolation. Markets and hierarchies by themselves are not well-equipped to govern the complex mixture of competition and co-operation particularly needed for the exploitation of new technological opportunities and the often collective, evolutionary technological learning processes (Teece 1992; Chang 1994; Cawson *et al.* 1990).

The importance of governance for the efficiency of the system of innovation has been recognised in principle.[5] Equally, the significance of different governance aspects of the national system of innovation has been appreciated by some national system of innovation authors. Lundvall, for instance, emphasises:

> What makes the national system of innovation important is that the organised markets of the real world may be organised differently in different national systems and that the behaviour of agents rooted in different systems may be *governed* by different rules and norms (Lundvall 1993: 277; italics added).

Despite this kind of general acknowledgement, the actual processes of governance e.g. the way in which governance emerges and how the distinctive aspects of the national system of innovation work out in a particular sector have not yet been fully explored.

It is in this context that we wish to make a contribution to the further development of the national system of innovation concept, to move it beyond the rather *static* analyses of different national systems of innovation, along the lines implicitly pursued by Nelson (1993), towards a more dynamic view of the national system of innovation.[6] This will be sought through elaborating on the *particular dynamics* of the national system of innovation and its underlying political process in a specific sector, and by using the governance concept as advanced by, for example, Streeck and Schmitter (1991), Streeck (1993), Campbell *et al.* (1991) and Hollingsworth *et al.* (1994a).[7]

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[5]So, for example, Chesnais (1986: 120) once pointed out the importance of governance and the co-ordination process in determining the whole size of the innovation system, as follows: 'The existence of appropriate non-market or para-market co-operation and co-ordination mechanisms facilitate the flow of information and provide them access to key external advantages . . . The strengthening of forms of co-ordination and co-operation . . . may lead to a development of the externalities on which competitiveness can build and an expansion of the total system within which industrial and technological learning processes can take place'.

[6]I owe this to a comment from Freeman.

[7]It rejects a purely economistic explanation of competitive performance, but it stresses the socio-political dimension: by arguing that economic action is shaped, not just by markets and private property relations, but also embedded in, and modified by, local institutional contexts of a non-eoncomic kind. For these governance authors, economic action is a special case of social action and, therefore, needs to be co-ordinated or governed by institutional arrangements. Their primary research interest lies in determining

This governance concept is receptive to the notion of power and politics and thus particularly appropriate for analysing the socio-political process as a determinant of the (particular) dynamics of the Korean innovation system in the semiconductor industry. Specifically, the argument of Kitschelt (1991), among others, is that success or failure depends not only on a match between the properties of technology in individual sectors and the national institutional capabilities, but also on the ability to translate these properties and capabilities into efficient sectoral governance structures.[8]

Unlike the transaction-cost economics approach to the question of the appropriate institutional arrangement for sectoral governance (see the critique by Traxler 1994: 14f), such authors pay proper attention to the important social and political context of governance. So, from their perspective, each industry is, for example, viewed as a matrix of interdependent social exchange relationships, or transactions, that must occur among organisations (either individually or collectively) in order for them to develop, produce, and market goods or services (Lindberg *et al.* 1991: 6). It is particularly for this reason that the governance concept appears to be useful for the following analysis of the very much *politically-institutionally shaped* process of Korean semiconductor development.

Tracing the historical evolution of interactions among state, market and firms, as is here proposed, is essential because the issue of how governance modes affect sectoral competitiveness is not straightforward. The relative efficacy of the individual governance mode must be analysed case by case. We shall also try to explain why such a specific governance mode has emerged.

4. The Historical Evolution of Governance and the Growth Dynamics of the Korean Semiconductor Industry

In this section, the objective is to show how the three critical variables of the state, market and firm have sometimes pulled together and sometimes conflicted with each other, and how such a complex interplay of these variables has affected the sectoral governance and hence the particular growth dynamics of the Korean semiconductor industry. With the sectoral governance here being conceptualised as the result of the dynamic interplay of firm, state and market dynamics, the resulting governance structure is then viewed in accordance with the existing governance concept (e.g. Campbell *et al.* 1991; Hollingsworth *et al.* 1994b) as having an important bearing upon firms' performances in a particular product or sectoral area, both as an institutionalised constraint and as an opportunity for their implementation of strategy.

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how economic activities are organised, the origins of these particular organisations and their effects upon the competitive performance of firms and sectors.

[8]Here his argument serves as an *a priori* argument to provide an explanation for Korea's DRAM success by the combination of sector-specific technological and economic factors and national-level political-institutional variables.

The historical development process of the industry (1965-1995) will be divided into two periods before and after 1983. The year 1983 constitutes the historical turning point in the development of the industry, when Korean firms like Samsung entered into Very Large Scale Integrated (VLSI) production. This consequently resulted in a qualitative change of the industry, from simple assembly production to sophisticated wafer-processing production. The following historical analysis indicates significant variations in the governance structure as well as in the role of the Korean state across these two time periods.

4.1 Limited development within the international division of labour, until 1983

Until 1983, the match of interests between the Korean state and foreign investors with respect to semiconductor assembly brought about limited developmen, with Korea acting as a semiconductor assembly site within the constraints of a hierarchical international division of labour. This continued until 1983, when Korean firms began to enter the production of VLSI chips.

4.1.1 Foreign investment, hierarchical governance and export promotion policy in the 1960s

The history of the Korean semiconductor industry started with the foreign direct investment (FDI) of US firms like Fairchild and Motorola in the mid 1960s. These were increasingly investing in low-wage countries, especially in South-East Asia, in order to reduce their production costs. Korea benefited from this trend and could make its very first start as a simple assembly site for foreign companies practising a hierarchical international division of labour.

Until 1965, when the first direct investment of the US firm, Komy, took place, the Korean electronics industry was in a very rudimentary state. The export share of the industry was only about 0.9% of the whole of manufacturing industry in 1965, and the only meaningful export product was transistor radios. This situation then changed radically, soon after the US investment started (Cho, H.S. 1992). US firms like Motorola let the transistors be assembled in Korea, then later also simple integrated circuits (ICs) for consumer electronics. Thanks to the US investment, the Korean semiconductor industry grew very quickly, at least quantitatively. Semiconductor exports amounted as early as 1969 to US $35 millions, representing 5.6% of total Korean exports, with semiconductor products becoming the country's fourth most important export product (EIAK 1981; Yun, J.R. 1990: 70ff).

The main vehicle for industrial growth in Korean semiconductors in this period was provided by the subsidiaries of US semiconductor firms like Fairchild and Motorola. The share of their IC products in total Korean IC production amounted to between 95% and 99% (Cho, H.S. 1994, 86). The subsidiaries of the US investors were just enclaves without any forward or backward linkages with the local Korean economy. They merely specialised in the simple assembly of transistors and ICs for the purpose of export, with the necessary materials and production equipment all being imported (EIAK 1981: 202). This development pattern had hardly changed by the beginning of the 1970s, when Japanese firms like Sanyo and Toshiba invested in Korea (EIAK 1989, 117f). Although both American and Japanese investments contributed to the rapid expansion of the industry, its quality hardly improved. Until the beginning of the 1980s, the Korean semiconductor industry remained very much restricted to the status of a simple, labour-intensive assembly site (Cho, D.S. *et al.* 1994: 92).

The dominant governance structure of the Korean semiconductor industry in this period was the hierarchical firm (i.e. the foreign investor). The economic activities of the Korean semiconductor industry were co-ordinated and controlled mainly through the strategies of the globally operating US (or Japanese) semiconductor firms. Korea was integrated and bound into the world market dynamics, not by the invisible hand of Adam Smith, but by the 'visible hand' of the foreign firms.

This governance structure was merely enhanced and supported by the complementary policies of the Korean state (Kim, H.K. 1991: 427ff; Yun, J.R. 1990). The capacity of the Korean state was heavily constrained by the existing international hierarchical division of labour, but there was no attempt at all on the part of the Korean state to help indigenous firms to build their own dynamic competitive advantages over the longer term. So there were no policies such as enhancing the local technological learning process. The state policy was solely one of encouraging FDI in Korea; for example, by establishing the export zones in Masan and Kumi (Kim, H.K. 1991: 427ff; Paek, N.K. 1981: 243f).

Despite the enactment of the law for the promotion of the electronics industry (1969) and the eight-year plan for the industry, the Korean state pursued no explicit policy to promote the semiconductor industry. This was largely because of a lack of interest of the Korean state in the semiconductor industry (and likewise in the electronics industry), apart from its limited interest in their export potential (EIAK 1989, 73ff). However, the rapid development of the Korean semiconductor industry into a significant export industry, and above all into an important source of foreign currency through foreign investments, awoke the interest of the state in the semiconductor industry, given the extreme need of the state to earn foreign currency. This was particularly important in view of the decrease in financial aid from the USA, until then the major source for financing imports, and hence the pressure to increase Korea's export and growth performance. At the same time, widening budgetary deficits and inflation were restricting the ability of the Korean state itself to fill the gap.

Otherwise, the state authorities of the time seem to have had no strategic foresight with respect to the semiconductor industry. For them, the semiconductor industry was not a special, strategically important, industry, but just one of many industries with apparently good export potential.[9] Nonetheless, the general political and institutional changes

[9]This is, for example, clearly recognisable in the history of Anam, now the world's biggest semiconductor assembler. According to the founder and CEO of Anam, Kim, H.S., Anam entered the assembly of

involved in achieving this goal of export promotion were to have far-reaching and significant implications for the growth dynamics of the Korean semiconductor industry over the following decades.

The most important of these changes came during the era of military rule, in particular from 1961 to 1964 (prior to the period that we are discussing here). Institutional reform was introduced, since President Park's interests in securing domestic legitimacy demanded a reversal of the drift of the preceding Rhee period. According to Haggard (1988), the military rulers were willing to give a group of incentive-oriented bureaucrats the political space and strong support that had not been available under Rhee. Thus a series of centralised, and insulated institutions for economic management were built around the task of bringing about rapid industrialisation, keeping political parties and electoral politics on the periphery of the policy-making process and establishing new instruments of policy (Chu, Y.H. 1989).

Of the institutional changes, the most important was the seizure of control by the state over the banking sector, which provided it with the crucial credit instrument for directing industrial development through the subsequent decades. This arrangement institutionalised the control of the planning technocrats over monetary instruments, establishing the base for the politics of reciprocal subsidy between the Korean state and the *chaebol* that have since characterised the Korean development process. This came with a tacit alliance between the Park regime and large-scale domestic business, which emerged because of the pressing political need to deliver a rapid and visible economic success (Janos/Sakong 1980; Cheng/Haggard 1987; Haggard 1988; Chu, Y.H. 1989: 659ff).

4.1.2 The HCI-drive era and implications of the politics of reciprocal subsidy in the 1970s

The 1970s was the decade in which the Korean state demonstrated its remarkable ability to mobilise resources and to pursue its policy goals on the basis of a radically reorganised state structure. The powerful policy instruments, and the insulated and centralised state structure, made possible a state-led push into the areas of heavy and chemical industries between 1973 and 1979.

In 1973, the government announced the 'Heavy and Chemical Industry (HCI) Promotion Plan', which was the direct result of executive initiative (Haggard/Moon 1986). This aimed to build a self-sufficient economy through HCI against the decreasing comparative advantage of light and consumption industries. Because of external world market

semiconductors at the end of the 1960s upon the recommendation of the then minister of the economic planning ministry. And the reason why the minister recommended the business of semiconductor assembly was simply because of its then good export potential. The fact that the minister recommended equally the porcelain industry for its good export potential indicates the lack of any other strategic consideration concerning the semiconductor industry (see Kim, H.S. 1989: 366ff).

conditions, as well as the increasing wage levels in Korea in the 1970s, the then predominant export model based upon labour-intensive light industrial goods, had become threatened. The export ratio decreased significantly, and Korea's foreign debt rose to a dangerous level. Nevertheless, the real cause of the HCI-drive policy had more to do with political rationality than with purely economic rationality.

In fact, the increasing economic problems posed a major burden on or threat to Park's regime, particularly as its political legitimacy very much depended upon maintaining the country's growth rate. The presidential election of 1971, when President Park achieved victory only by a very narrow margin against Kim Dae Jung, engendered a real feeling of political crisis among the then rulers. So the democratic constitution was abandoned, and there followed a radical, state-initiated, targeting policy aiming at rapid construction of HCI industries such as shipbuilding, machinery, steel and petrochemicals. Security policy interests also mattered considerably in this HCI-drive policy. In the face of the Nixon doctrine, and in particular the imminent reduction of the numbers of US armed forces stationed in Korea, the Korean state considered the rapid expansion of HCI industries as useful to strengthening the country militarily (Cheng/Haggard 1987).

Where did the electronics and semiconductor industries stand in this era of the HCI drive? The general objective of the promotion policy for electronics industry was to be found, according to EIAK (1981: 75f), most of all in the fourth five-year economic plan (1977-1981). What was new here was that a strong emphasis was placed upon the import substitution of key components and parts of electronics products. In the face of an extremely high dependence on imports, the import substitution of key components was considered to be a necessary condition for the improvement of international competitiveness and the value-added ratio of the electronics industry.

It was also at this point that a new policy objective for the semiconductor industry was formulated, which went beyond the hitherto pure export-promotion role, and aimed at the deepening of the industry's structure. In 1975, the Ministry of Trade and Industry formulated a six-year plan for the import substitution of the six key electronic components, whereby much emphasis would be placed upon wafer-processing. The Korean semiconductor industry should grow beyond its existing role of simple assembly and thus make a significant contribution to the increase of the value-added ratio of the electronics industry (for details see Cho, H.S. 1992).

This new policy objective reflected the radically altered situation of the growth of the Korean semiconductor industry. An official of the Ministry of Trade and Industry reported at the time that the Korean state authorities had become far too painfully aware of the limitations of the industry's growth within the existing international division of labour. This was because of the ever-increasing automation of assembly processes in the industrialised countries, and the transfer/relocation of production since 1973 from Korea to other developing countries with cheaper wages (Rhy, Y.J. 1989: 318f).

Although the electronics industry was officially declared (not least because of its export potential) a strategically important industry to be targeted, the actual effect of its promotion was believed to be little. The electronics industry was in practice considered less important than the steel or chemical industry. The Electronics Industry Association of Korea (EIAK) hence made the criticism that even the few promotion measures, such as subsidised credits or tax benefits, were of hardly any use to the development of the industry (EIAK 1989**:** 202f).

It therefore comes as no surprise that the construction of the very first wafer-processing production capacity in Korea came into existence under a private initiative, without any noticeable help from the state. This foundation of the Korean wafer-processing production was laid in 1974 by the joint venture company, Korea Semiconductor Inc. (KSI). KSI gave a big impulse to the Korean semiconductor industry for its qualitative leap, by developing and producing CMOS Large Scale Integrated (LSI) chips for the first time in Korea. Because of its financial problems, it was soon after sold to Samsung, and renamed in 1978 Samsung Semiconductor Inc. .

KSI had developed ten different transistors for black and white TV and audio equipment. Through these products, KSI had been able to achieve the whole production process, from design up to wafer-processing (Cho, H.S. 1992). KSI's technological success then encouraged other Korean firms to enter into wafer-processing, firms strongly attracted to the segment, but which had previously not dared, because of the challenges of sophisticated wafer-processing technology. In particular, electronic firms like Goldstar became more interested in the production of key components such as chips. This arose not least in the face of the increasing integration of system functions on to individual chips and their increasing importance for the competitiveness of Goldstar's electronic products (Kim, H.K.1991: 432f).

In addition, most Korean electronics firms were suffering at that time from an unstable supply of semiconductors from Japan. The Japanese semiconductor producers, often members of vertically integrated keiretsu, were suspected of controlling the chip supply to their rival Korean electronics firms, in order to compete in the systems market (Cho, H.S. 1994; 102f). This was why Samsung tried to lessen this problem through the acquisition of KSI, while Goldstar set up Goldstar Semiconductor Inc. in 1979 and started wafer processing after 1980 (see Cho, H.S. 1992). Despite these efforts, the development of the Korean semiconductor industry in this period had not significantly changed. The share of wafer-processing remained much the same (Yun, J.R. 1990: 107).

What kind of role did the Korean state play in the development of the semiconductor industry in this period? Even the few policy measures to promote the industry were very limited in their effects.[10] Rather more important were the almost routine *politics of*

[10]For example, it is very much the case with the Korean Institute for Electronic Technology (KIET), which was founded by the state for the promotion of electronics industry. KIET was to provide the semiconductor and computer firms with technology development. Despite some helpful works, according to EIAK (1989, 144f), it was by and large inferior to the private electronics firms with respect to its quality of manpower and research capability. Thus, the major initiative eventually remained left to the private companies (Hong, S.G. 1993b). See also Cho, H.S. (1992) for the details of other policy measures and their limited effects.

reciprocal subsidy, played between the state and the *chaebol*, which became fully fledged in the HCI-drive era. The overall goal of the HCI policy was to encourage the large firms, in particular the *chaebol*, to become 'faithful partners' in the new development of these heavy and chemical industries. The state wanted to utilise them as the engine for achieving their rapid growth (Haggard/Moon 1986; Leipziger 1987). Thus, the state selected among the potential entrants and provided them with preferential loans, tax reductions and other incentives.

Among the various incentives and measures, credit facilities were the most important and most frequently used policy instrument for encouraging large firms' entry into the HCI industries (see Ikenberry's classification of policy instruments, 1986). In Korea, the benefiting firms received credits with negative real interest rates. In the second half of the 1970s, the state channelled amounts of capital into the HCI industries large enough to alter radically the context of private investment decisions. The firms, above all the *chaebol*, which invested in the targeted industries such as steel and petrochemicals, received so-called policy loans. The share of these policy loans amounted to as much as around 60% of that by the big Korean banks (Han, J.H. 1993).

The important condition attached to these loans was that the receiving firms must export their products almost from the outset, and prove their export performance. This condition of export performance made up, as Amsden (1989) argues, the reciprocal subsidy between state and firms, and worked as a positive pressure for the subsidy-receiving firms to increase their production efficiency in order to be able to export their products. Although the state's policy was in the first place an investment policy, with the aim of expanding the HCI industrial base, this steering process by the Korean state, based upon the politics of reciprocal subsidy, also had positive effects for the recipient firms' performance.[11]

The implementation of the HCI policy was to have significant implications for the industrial development of semiconductors as well. Above all, it brought about economic concentration and the clear dominance of the *chaebol*, factors which subsequently favoured their entry into DRAM production. It is reported that the ten largest *chaebol* accounted for 20% of the entire Korean industrial production at the beginning of the 1980s, as the result of the HCI policy (*The Economist*, 3 June 1995). Owing to such a huge resource concentration in a handful of *chaebol*, they could move quickly into the extremely capital-intensive production of DRAMs and eventually overcome difficulties arising from huge financial losses in the 1980s.

Thus, by and large, the reciprocal subsidy was to work out favourably for the large DRAM producers in the 1980s. However, its major drawback lay in the negative consequences for the development of small and medium-sized firms, and thus for the semiconductor machinery and materials industries. Most small and medium-sized firms, left aside by the politics of reciprocal subsidy, had no means of access to these scarce

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[11]This is not least due to the virtuous cycle of export and technological learning as well as performance improvement (see also Hobday 1995).

resources. The extremely poor development of the supporting industries can thus be traced back largely to the way the politics of reciprocal subsidy shaped industrial structure and strategy in Korea.

4.2 The chaebol-initiated leap and breakthrough after 1983

The 1980s constituted a turning point in the history of Korean semiconductors. This was the decade in which the big leap was made possiblefrom simple assembly production to an important DRAM production centre. The beginning of the VLSI era in Korea was initiated in 1983 by the *chaebol*, which had grown enormously during the previous HCI-drive era, and early on recognised the great economic potential of the semiconductor industry. The much longed-for breakthrough came in 1987, arising out of favourable world market conditions. These were mainly induced by the international semiconductor politics being conducted between the USA and Japan.

4.2.1 Entry and waiting for a 'window of opportunity': the efficacy of chaebol-governance

In the 1980s, the *chaebol*, above all Samsung and Hyundai, were searching for a future business area, aiming to transform of their industrial base into one that was more high-tech oriented. While Samsung came to the decision to enter the production of VLSI chips via its electronics business, Hyundai decided on chip production as a way to fulfil its wish to diversify into electronics. Samsung's and Hyundai's entry into VLSI production indicates that the semiconductor industry was emerging as a new competitive area for the biggest Korean *chaebol*. With Goldstar's subsequent entry into VLSI production, all three of the biggest *chaebol* came to participate in VLSI production.

1) Samsung's entry and strategy of focused DRAM production

The big leap of the Korean semiconductor industry came about mostly through the decision of Lee Byung Chul, at the time CEO of the Samsung Group. He decided in February 1983 on a massive investment in memory chip production, which was considered as a very bold decision. At that time, Korea was still a simply assembly production site, and even in 1983, the share of wafer-processing in the entire semiconductor production amounted to only 4.3% (Kim, H.K. 1991, 433).[12]

In the 1980s, after painful experiences during the first and second oil crises, Lee and his conglomerate were in search of a promising new business area. Samsung was also under increasing competitive pressure from Goldstar in the domestic consumer electronics market,[13] and this domestic market pressure acted as a 'push factor' in Samsung's active

[12]The author is not entirely clear how it's measured. We presume % of the total sales or value-added.

[13]I owe this to Sungsoo Seol's helpful comment.

search for a new business area.[14] Of importance for this bold strategic decision may also have been Samsung's 'information-gathering capacity' (Weiss, L., interview 1995), as a result of its long-standing activity in the consumer electronics business. Early on, Samsung had become conscious of the economic potential of chips as well as their strategic importance for their core business. Moreover, according to the official strategy of the company, Samsung Electronics Co. (SEC) was suffering from frequent delivery problems with chips imported from Japan.[15] All these factors prompted Lee Byung Chul to venture into the VLSI chip business (SST 1987: 187ff).

After his decision, Samsung moved very quickly and had already started the development of 64K DRAMs in the same year. The year 1983 thus marks the beginning of the VLSI chip era in Korea. DRAMs were chosen as Samsung's main semiconductor product for the following reasons (*Kwa-Hak Dong-A* 1989; SST 1987: 193ff):

- In the first place, the market size was an important criterion for product selection. Static Random Access Memory (SRAM) chips had been initially considered, but, because of their much smaller market size, Dynamic RAMs (DRAMs) and their larger markets were eventually chosen.

- Secondly, having seen the successful catching-up process of the previous-generation latecomer Japanese firms in the DRAM area, Samsung was convinced that a newcomer would also be able to compete successfully with well-established firms.

- Thirdly, technological aspects played an important role for the product choice. The design-intensive products, such as microprocessors or Application Specific ICs (ASICs), were not taken into serious consideration at all.[16] However, in the case of DRAMs, Samsung felt quite confident — in view of their relatively simple design structure — that it would be able to compete with other companies, if it were able to master the production technology.

So Samsung set up a detailed plan, according to which about 50% of Samsung's entire semiconductor products should be DRAMs (SST 1987, 193ff). This way, Samsung was able to make a clear decision concerning its corporate strategy, which aimed at achieving economies of scale and cost competitiveness through a narrowly focused concentration on the carefully chosen DRAM segment.[17] Up to now, nobody has really disputed the appropriateness of Samsung's product selection (Cho, D.S. *et al.* 1994; Song, Y.J. 1995;

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[14]I owe this insight to Nick von Tunzelmann.

[15]As we have already shown, even by mid 1990s the aims have not yet been achieved. There are still few linkages between the company's major products (i.e. DRAMs) and its electronic system products. It still imports heavily chips from Japan for its electronic products.

[16]Weak design capability is a very common problem among the Korean electronic firms, and this is largely a historical legacy of Korea's development process with heavy dependence upon foreign components, as Kim Hyeon Gon (Goldstar) makes clear as follows: "Our biggest weakness is in design, not only chips but the design and understanding of the system in which chips are used. In the past, we bought the components, we used them, we assembled them, but we never designed or created the system from the beginning" (Interview in: Warshofsky 1989, 225).

[17]Jun and Kim (1990, 97ff) call it a "strategy of cost leadership with focus".

SST 1987), in particular with respect to its *chaebol* structure and the specific technological characteristics of DRAMs.

Essential for DRAM competitiveness are manufacturing efficiency and incremental process innovations; more so than radical technological innovation capacity. The strategy to perfect the established manufacturing process, with the aim of improving the yield rate, is essential for market competition. This is certainly true in the case of DRAMs, technological advance proceeds along an established development trajectory and mainly through the increasing degree of integration (Florida/Kenney 1990; Hobday 1991; Hilpert *et al*. 1994; Robertson/Langlois 1995). Moreover, Korean firms like Samsung have become familiar with incremental process innovation, not least owing to their long-standing experiences in reverse engineering.

In the following years, Samsung's concentration on DRAM production turned out to very an effective entry strategy. Soon after the selection of DRAMs as the major product, Samsung successfully developed 64K DRAMs (November 1983). Technologically, this was a big leap for the Korean semiconductor industry, from relatively simple LSI technology to the cutting edge of VLSI technology. Samsung's successful development of 64K DRAMs was achieved in co-operation with foreign companies. Thereby, Samsung proved to be extremely capable of adopting and integrating the imported technology. Samsung imported the 64K DRAM and 256K DRAM technologies from the US firm, Micron Technology, and 16K SRAM technology and 256K ROM technology from the Japanese firm, Sharp (SST 1987). These imported technologies were then incrementally improved by Samsung's task-force team. In the initial phase, the licensing of foreign technology had played a crucial role in Samsung's product development. Over the years, however, its own development activities became more important (SST 1987).

Samsung's later successful development of 1M DRAMs in 1985 indicated that it was then in a position to carry out its own product development, also mastering the relevant DRAM design technology for the first time. Samsung had already set up in 1984 a modern chip factory for the mass production of 64K DRAMs and exported them for the first time to the USAin autumn 1984. Successful 256K DRAM development, with the assistance of Micron Technology, then followed at the end of 1984. These endowments were made possible mostly by Samsung's efficient adoption and learning strategies. Soon after Lee Byung Chul's decision, SST International Inc. (renamed in the same year as Tristar Semiconductor Inc.) was set up in Silicon Valley as a technological outpost. It made a significant contribution by developing products successfully, which were then transferred to the parent company in Korea, Samsung Semiconductor and Telecommunication Co. (SST), for mass production. This subsidiary played a crucial role for Samsung's technological development, especially during the initial production phase, when the company did not own any in-house R&D capacity (SST 1987). In parallel, a huge effort was then made to integrate the transferred and imported technologies and to improve hem, so as to create an efficient production system for them. The company's own research institute was set up for this purpose. A task-force concept was also implemented, which proved extremely effective in increasing yield rates (interview with SEC 1995).[18]

As for the supply industry, Samsung's strategy was based, according to Choi Y.R. (1994), upon a conscious strategy of effective consumption of foreign innovations (e.g. the innovations embodied in imported semiconductor production equipment). This involved an active, selective import strategy for semiconductor machinery and materials based upon Samsung's acceptance of an eventually high import dependency. This allowed Samsung to focus mainly upon the improvement and optimisation of the production process.[19] It was this strategy of active adoption, improvement and integration of the imported technology and goods, which later enabled Samsung (and also other Korean chip producers with similar strategies) to achieve an even better level of manufacturing efficiency and yield rate than its Japanese competitors..[20].

2) Hyundai's diversification and trial-and-error process

Chung Ju Young, then president of the Hyundai *chaebol*, showed himself even more risk-taking in his decision for semiconductor production than Lee Byung Chul of Samsung. For Hyundai was a complete novice in the electronics industry. Chung Ju Young felt the need for Hyundai's diversification into the electronics industry at the beginning of the 1980s; partly because of the increasing use of electronics in the automobile industry, one of Hyundai's core business areas. Moreover, he wanted to expand and transform Hyundai's industrial base well beyond its core businesses in automobiles, shipbuilding and other heavy industries, and to gain a foothold in the obviously promising electronics industry (HEC 1994). Thus in 1983, Hyundai Electronics Co. was founded, with Chung

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[18]A strongly production-oriented, technology-management concept underlies the task-force team. The usually clear division of work process between planning, development and production is overcome by an organisational integration by teamwork. People from the planning and R&D divisions, engineers and even production workers work closely together spanning the divisional boundaries, so as to realise an efficient production system. If a problem (e.g. a low yield rate) occurs, a task-force team would be formed, even under the direct control of high management level, and the problem was checked for its every possible source. Its members would come under enormous pressure, particularly because Samsung's concept was laid out as a race against time. However, it proved a highly effective method for understanding and learning semiconductor technologies in a short time (SST 1987, Choi Y.R. 1994, Bae, Y.H. 1995).

[19]According to Choi Y.R. (1994, 115ff), Samsung calculated that, even if it ought to rely on the outside sourcing of equipment and raw materials, it would acquire a strong competitive edge if it were able to manage the production activities through the strength of fine management and the capable in-house manpower of Samsung.

[20]In the case of Samsung, the yield rate in 4M DRAM production was reported in 1993 to be over 80% (*Chosawolbo* 1993, 6), and Hyundai's yield rate would be even higher (interview with HEC 1995). According to the Nomura Research Institute (NRI) (1993), the efficiency of the Korean semiconductor investment has constantly improved. Since 1990, it has become even better than that of the Japanese producers. Successful management of production equipment and the effective integration of imported machinery were identified as the major reasons. This research finding is obviously very much in line with Choi Y.R.'s (1994) emphasis upon the importance of effective "networking in resource mobilisation" for competitive performance and Samsung's capability to "stretch" its resource base, by effectively exploiting both in-house resources and outside sourcing.

Ju Young's strong commitment. Its main business activity was to comprise semiconductor production and industrial electronics (HEC 1994: 99f).

As for technology development, Hyundai pursued a dual strategy like Samsung's. A technological outpost, Modern Electrosystems Inc. (MEI), was set up in March 1983 in Silicon Valley, which was to transfer cutting-edge semiconductor technology to its parent company in Korea. In October of the same year, Hyundai Electronic Research Institute was set up, with the aim of rapidly constructing Hyundai's own technological base in Korea (HEC 1994, 106ff).

Hyundai had decided in favour of memory chip production like Samsung, albeit with a different memory product (SRAMs) as its main product (HEC 1994, 109). This product choice later proved to be a mistake, making Hyundai lose much time and lag far behind Samsung in competition in DRAMs. Hyundai initially chose SRAMs because it wanted to evade direct competition with Japanese firms in the DRAM market, which the latter already had under their control. However, SRAMs are technologically much more sophisticated than DRAMs, and Hyundai was unable to achieve a satisfactory yield rate. MEI and its parent company in Korea started with mass production of 16K SRAMs immediately after their development in December 1984, but they could not achieve a satisfactory yield rate until the end of 1985 because of faults in their chip design.[21]

So Hyundai switched later in 1985 to DRAM production. As it was then already too late for Hyundai to carry out its own DRAM development, it instead turned to subcontracting from foreign firms and importing foreign chip designs. After this change of firm strategy, Hyundai produced 16K SRAMs, 64K DRAMs and 256K DRAMs on the basis of chip designs and technology imported from the US company, Vitelic Corporation. However,Vitelic chips failed in mass production, and the yield rate was generally very low (with the exception of 64K DRAMs): in the case of 256K DRAMs, the yield rate remained under 30% (HEC 1994, 118ff).[22]

On the other hand, Hyundai's strategy of producing memory chips as a foundry for foreign firms under OEM agreements worked out rather well. Hyundai produced, from 1986 to 1988, 64K EPROMs and 256K EPROMs for the US company, General Instruments, and above all 256K DRAMs as a foundry for Texas Instruments between 1986 and 1991. This was of great help to Hyundai, as it was struggling with technological and financial problems. By producing Texas Instruments' 256K DRAMs as OEM chips, Hyundai could accumulate the necessary process technological know-how for 256K DRAM production, and thus improve its difficult financial situation. These

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[21]Unlike Samsung's American technological outpost, MEI (later renamed as Hyundai Electronics America) couldn't fulfil its function effectively. The products which were developed by MEI failed in mass production. MEI was later in 1986 (at the height of Hyundai's financial difficulty) sold to Siemens, and ever since then Hyundai's Electronic Research Institute in Korea has been in charge of the R&D for the chip production (HEC 1994, 126f; interview with HEC 1995).

[22]Vitelic was a rather small, joint-venture company, and its chip design was not appropriate for mass production (interview with HEC).

256K DRAMs from Texas Instruments became Hyundai's successful products, along with the 256K DRAMs which Hyundai developed on its own and successfully mass produced. Largely thanks to these two products, Hyundai could attain profitability in 1988 for the first time (HEC 1994, 138f).

On the whole, Hyundai encountered more difficulties than Samsung, who had at least certain prior experience in semiconductor production (EIAK 1989; 418). It took Hyundai much longer than Samsung to set up an efficient production system and to stabilise the yield rate. Hyundai paid a very high entry price as a complete novice in this area, through its altogether very costly trial-and-error process. Yet, ironically enough, such a costly process turned out eventually to be beneficial to Hyundai's subsequent progress in semiconductor production. In consequence, Hyundai became very much aware of the difficulty and the importance of process innovation. It has ever since been fully committed to 'never-ending improvement effort' (HEC 1994; 270), in order to increase manufacturing efficiency, soon achieving (i.e.by 1988) the best yield rate among the Korean semiconductor firms (HEC 1994; 140).

The particular importance of incremental learning-by-doing processes as the source of competitiveness in DRAMs can be further illustrated by Hyundai's experience of experimenting with imported semiconductor production equipment. Hyundai was by no means inferior to Samsung, as far as the already mentioned resource-stretching and exploitation capability was concerned. So Kim, C.U., from the Hyundai Research Institute (HRI), claims to be relatively unconcerned about Hyundai's high import dependence in the semiconductor production equipment industry.[23] He even attributes Hyundai's comparatively higher yield rate to its extraordinary capability to choose the best production equipment from all the available Japanese and American alternatives, and to integrate them effectively into its production system. This is above all because Korean firms like Hyundai benefit (quite ironically) from their long-standing experience and experimentation with imported machinery and its successful integration into an efficient production system. In comparison, Japanese chip producers may get "locked into" the continuing use of their own supplier firms' equipment, without really enjoying a wide variety of best available equipment (interview with HRI 1995).

3) Goldstar's "wait-and-see" and cautious strategy

Goldstar's comparatively late entry into memory chip production is mainly attributable to its CEO's less risk-taking and more cautious investment strategy (Cho, D.S. *et al.* 1994: 258ff). Up to the end of the 1980s, Goldstar concentrated mainly upon the production of logic chips and 4-bit and 8-bit microprocessors. It tried to keep the range of semiconductor products as mixed as possible, so as to spread the investment risk over diverse products. Goldstar's primary purpose thereby was, unlike that of Hyundai or Samsung, first to supply its own needs (Cho, H.S. 1992: 50f). Commodity chips like

[23]The import ratio of the Korean semiconductor industry in production equipment in 1994 (mostly steppers) was 91% (52% thereof from Japan). As for the semiconductor materials, the rate in 1994 amounted to about 40% (KSIA 1995a).

DRAMs were viewed by Goldstar as just complementary to reducing the overall production cost (interview with LG Semicon 1995; Warshofsky 1989: 223f).

However, this strategy failed, largely because of Goldstar's limited technological capability. According to Cho, H.S. (1992, 50f), Goldstar had for instance a great chance in 1984 to supply gate-arrays to the American firm LSI Logic, but its contract was cancelled because of the insufficient product quality of Goldstar chips. Goldstar decided only much later, in 1989, to enter the DRAM market, after having seen Samsung's DRAM success in 1987 and 1988. Goldstar's DRAM share of its semiconductor turnover was still only 28% in 1990 (*Management & Computer* 1991/1).

In order to catch up with Samsung in the DRAM race, Goldstar geared itself mainly to technology licensing agreements with foreign firms rather than to its own development. Goldstar could thereby profit substantially from its traditionally close contact and OEM contracts with Hitachi. So Goldstar could master the VLSI production technology relatively easily, by using the technology imported from Hitachi and the manpower recruited from abroad (Jun/Kim 1990: 138f).

It is important here to note that the three chip producers have, notwithstanding all their initial strategy differences, at least one thing in common: namely their particular structural advantages as *chaebol* companies. Through their incorporation as the big *chaebol*, they all have decisive structural advantages in terms of capital and manpower mobilisation as well as the opportunity for cross-financing (see below). Without having such an advantage, they would not have been able to start their new DRAM businesses so quickly. Nor could they have lasted through the hard times with huge financial losses until 1987, when a window of opportunity in the world markets for Korean firms finally opened.

For example, Samsung could attract the best manpower in the country to itself, thanks to its privileged and dominant position as the biggest Korean *chaebol* (KSIA 1993: 3). Samsung put them, together with other elites recruited from its various member companies, into its new target area of the semiconductor business. Ever since the semiconductor business was designated as the most important business of the Samsung group by the CEO, Lee Byung Chul, capital and the best manpower were all concentrated here (SEC 1994); it was granted the privilege of seizing the scarcest and most sought-after resources not only of the country, but also of the whole Samsung group. This was more or less the same in the case of Hyundai and Goldstar as well (see NRI 1993).

Korean *chaebol* are hierarchically structured and centrally organised. The member companies are grouped around the chairman and central office, which is responsible for resource allocation and often for personnel decisions at the whole *chaebol* group level. This structure enables a quick and unified support for a new business area. Particularly important is the fact that *chaebol* could receive long-term risk capital through cross-financing. The member companies hold company shares mutually, and the capital is often transferred from one member company to another. This *chaebol*-specific property and firm structure proved to be of great benefit to the Korean newcomers in this extremely capital-intensive semiconductor business.[24] They could afford a strategic long-term orientation, despite certain initial losses, and were structurally better equipped to survive through financially hard times than most US or European companies.

In the case of Samsung, for instance, the sum of the required capital investments in 1984 and 1985 is reported to have amounted to 300% of its entire semiconductor turnover (Han, J.H. 1993: 257). This immense capital need was covered through capital transfer from the then profitable telecommunication division, as well as from Samsung Electronics Co., which acted as a 'cash cow' (Jun/Kim 1990; Han, J.H. 1993).

It was more or less the same with Hyundai. The profits from other member companies were inserted into the semiconductor business, and compensated for its high initial losses during the market entry phase. The CEO, Chung Ju Young, reportedly allowed for initial financial losses for up to the first five years (HEC 1994: 215). In the first two years, 1983 and 1984, no turnover was achieved at all; while in 1986 the turnover amounted to just a tenth of the whole investment cost, and in 1987 to only a half of it (HEC 1994: 264). This difficult financial situation lasted until 1988, when Hyundai for the first time had a higher turnover than its investment costs.

The Korean companies experienced losses as big as several million US dollars during the market crisis around 1985. The price of DRAMs began to fall drastically, shortly after Samsung started production of 64K DRAMs and entered the market in September 1984. The price of 64K DRAMs was around US $3 in the middle of 1984, but the price dropped by an order of magnitude to US $0.30 by the middle of 1985, as a result of DRAM oversupply (caused by an early recession of the US PC market) and the subsequent, aggressive pricing policy of the Japanese DRAM makers. The market recovered no sooner than mid-1987 (Tyson 1992; Borrus 1988; EIAK 1989, 418ff). Samsung's cumulative deficit totalled around 200 billion Won (about US $0.25 billion) by the end of 1986 (Choi, Y.R. 1994). Nonetheless, Samsung continued with its product development as well as its investment in new production capacity. Goldstar carried on producing chips for its own in-house consumption. Hyundai sold its R&D institute in Silicon Valley to Siemens, but continued with its further investment in DRAM production facilities (HEC 1994).

Having once failed with DRAM sales and thus the recovery of the invested money for the further development and production of the next generation of chips, companies would usually find it extremely difficult to remain in the semiconductor market. However, Korean chip makers could do so, thanks to the *chaebol*-level co-ordination of financial resources and hence the financial 'cushioning' effect. *Chaebol*-governance implies here a specific combination of 'hierarchy' (built around the CEO and central office) and 'network' (consisting of a *chaebol*-level network organisation of member companies). Financial and human resources could be mobilised very quickly through the internal

[24]The extremely high capital intensity is an important characteristic of the semiconductor industry (Bagger 1993). Above all, the cost of semiconductor manufacturing facilities is escalating because of the increasing degree of IC integration (*Financial Times* 29. August 1994, Hilpert *et al.* 1994).

transactions and co-operation within the *chaebol* on a non-price basis, which permitted well-focused and effective investment in the new semiconductor business. Moreover, the *chaebol*-governance proved good for enduring the initially hard times. So *chaebol*-governance has been very effective in terms of its performance capacity during the market entry phase and the ensuing hard times, and an important *institutional* factor for the quick (as well as the ultimately successful) market entry of Korean companies into DRAM production, typically characterised by very high economic entry barriers.

Furthermore, the *chaebol*-governance appeared to fit in very well with the specific technological innovation characteristics of DRAMs, or the 'technological regime' (see Malerba/Breschi 1995).[25] The technological advance of DRAMs proceeded mainly through the ever-increasing IC integration capacity, and the increasing integration of new-generation DRAM chips eventually resulted in a continuous demand for product and process innovations. The incremental process innovations and contingent learning effects from manufacturing (e.g. learning-by-doing effects) constitute an important source of technological innovation and thus of productivity increase. The sensitivity of the chip-manufacturing process brought about a distinctive form of learning-by-doing. The higher yield rate was usually achieved through long experimentation over details in the manufacturing process (Howell *et al.* 1988; Borrus 1988; Tyson/Yoffie 1991), as already mentioned and proven in the case of Korean DRAM producers like Samsung and Hyundai.

The innovation effects achieved in this way plus the associated technological capabilities constitute a firm-specific pattern of knowledge. This means that they accumulate at the level of each individual learning firm, and constitute implicit, asset-specific knowledge (see for these terms, OECD 1992), which is usually difficult to transfer to other firms. This in turn has important consequences for the pattern of industrial competition and governance structure in the DRAM segment. The existence of such firm-specific learning effects generates dynamic economies of scale and hence significant entry barriers for newcomers. Moreover, the learning-by-doing effects make the micro-level of each individual firm the most important level of the technological innovation process.

In this way, each individual firm's capability to achieve effective learning-by-doing is likely to become the most decisive competitive determinant. So in the case of DRAMs, Korean producers seem to have been hardly penalised by the lack of network quality in the Korean national system of innovation, as long as they were capable of maintaining their individual firm-level (*chaebol*-level) learning-by-doing and manufacturing efficiency. However in a case like ASICs, a closer level of interaction between the big chip producers and the mostly small and medium-sized user firms would be required, and therefore the governance implications of different product segments for effective technological innovation would be significantly different.

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[25]The links between technological properties of different sectors and the matching governance structures are not yet firmly established, even though some promising research is being conducted in this area (e.g. Malerba/Breschi 1995). Hence, our argument here is indicative rather than fully conclusive with respect to technology and governance structure.

To what extent has the distinctive political process in the 1980s mattered for the genesis of this kind of effective *chaebol*-governance? While the implications of the politics of reciprocal subsidy in the 1970s mattered for the emergence of *chaebol*-governance, the lack of any interventionist regulation efforts by the state in the 1980s was highly conducive to the continuing *chaebol*-governance. The lack of politically motivated (and economically dubious) activities of the Korean state with respect to cross-financing activities among the *chaebol* member companies in the 1990s deserves a particular mention on that score alone. For the Korean state's exercise of "self-restraint" was by no means a matter of course, and the political process leading to its relinquishing control of firms merits particular attention.

The co-ordination and organisation of DRAM production activities by each individual *chaebol*'s strategy and structure took place against the background of the largely politically motivated withdrawal of state authorities from an extensive intervention policy at that time. The Korean state was, because of the internal and external political-economic conditions and its own policy changes, then unwilling and unable to pursue a sectoral targeting policy for the semiconductor industry. It started to commit itself to promotion of the industry only after Samsung's much publicised success in DRAM development. Otherwise, the co-ordination of the relevant technological and economic activities was left to the *chaebol* alone, establishing *chaebol*-governance as the dominant governance mechanism ever since.

By the end of the 1970s, the Korean economy was troubled by a high inflation rate and a huge trade deficit, and also hit hard by the second oil crisis. The new military regime of the ex-general Chun, who rose to power through a coup, responded with a policy of deregulation and liberalisation in the face of the ever-increasing criticism of the high-inflationary HCI policies and excessive state intervention. At this time, the uppermost policy objectives for the new state actors were the introduction of price stability and market mechanisms, as well as the state's withdrawal from an active intervention policy. This way, Chun wanted to dissociate himself from the much criticised HCI-industry targeting policy of the previous President Park (Cheng/Haggard 1987, 17f).

This general change of policy priority resulted in a weakened position of the Ministry of Trade and Industry, the key state actor behind the HCI-push policy, *vis-à-vis* the macro-economists of the Economic Planning Board, whose interest lay more in price stability than in sectoral promotion. The Korean state became more active with respect to the sectoral promotion policy only much later, after Samsung's much celebrated DRAM success in 1986 brought about a national consensus among various ministries for the selective promotion of the industry.

Moreover, the external conditions in the 1980s strengthened Korean state authorities' inclination against a sectoral targeting policy . The ever-intensifying US trade policy pressure since the beginning of the 1980s put serious constraints upon the Korean state's autonomy for industrial policy-making. US pressure has become ever since the most significant structural determinant of the politics of the Korean semiconductor industry (see Hong, S.G. 1992).[26]

Against such a background, the state was in terms of initiative taking clearly lagging behind the initiatives taken by the *chaebol*. Only after having seen the visible success achieved in the area of DRAMs did the state subsequently try to catch up with firms' initiatives and their already established DRAM trajectories.[27]

Owing to the lack of a significant sectoral promotion policy by the Korean state, the *chaebol* did not get any meaningful direct help from the state, during their difficult entry phase and hard times from 1983 to 1986, which resulted from the sharply falling price of DRAMs in the world market. Nor could they count upon a high-quality national production and innovation system. Samsung and Hyundai, for example, had no other alternative than to go abroad and to set up their technological outposts and R&D institutes there, as neither the qualified engineers nor an efficient technological infrastructure were available to them at home. In fact, they had to create and organise almost everything on their own, but were largely in a position to do so because of their concentration of resources and the *chaebol*-governance. The *chaebol* then fought to secure their entry, and maintained their foresight and enormous financial investment, persevering through the extremely hard times with huge financial losses, and persisting until the 'window of opportunity' in the world market dynamics opened up.

4.2.2 Breakthrough, world market rewards and state policy supplement

In the second half of the 1980s, there came the much-desired breakthrough for Korean DRAM producers. A window of opportunity emerged in 1987 in the world market,

[26]Any sectoral promotion policy was viewed by the USA as an "unfair" trade practice. For fear of provoking a trade conflict with the USA, the Korean state actors even went so far as to persuade Samsung to postpone the official announcement of its successful 256K DRAM development in 1984 to one year later (SST 1987, 257).

[27]The plan of the Ministry of Trade and Industry for the structural deepening of the electronics industry in 1982 clearly indicates that the state had been lagging behind the firms in terms of initiative taking and strategy implementation. Here, the import substitution of chips required for consumer electronics industry had been planned for the mid 1980s at the earliest. Because Samsung however had developed 64K DRAMs already by 1983, and also successfully developed 256K DRAMs by 1985, the state had to change its plan (Bae, Y.H. 1995, 116). It had to adjust its plan to the firms' R&D progress, particularly to Samsung's. Moreover, the state had no effective R&D infrastructure at its disposal, through which it could have had pursued its own initiative for semiconductor technology development. Unlike in Taiwan, for example, where apparently the public R&D institute, Industrial Technology Research Institute (ITRI), made a significant contribution to the technological development of the semiconductor industry (Mathews 1995), the Korean ones were far too poorly developed to be of much use for the Korean firms' actual rate of technological advance. The only significant public institute in this area, the Korean Institute for Electronic Technology (KIET), could contribute to a certain extent to the import substitution of chips, but even its R&D capacity was regarded as being far too insufficient to absorb VLSI technology (Hong, S.G. 1993a; Kim H.K. 1991, Yun, J. R. 1990).

resulting not from free market forces but from the semiconductor trade conflicts between the USA and Japan, as well as their subsequent political regulation.

The escalating trade conflicts between the USA and Japan after 1985 (caused by the increasing market share of Japanese DRAM producers at the expense of US producers) resulted in the first Semiconductor Trade Agreement (STA), valid for five years (1986-1991). It aimed to secure access for foreign semiconductor producers to the Japanese market and to impose a ban on as well as monitor the alleged Japanese 'dumping' practices. In the face of the persisent criticisms of Japanese 'dumping', the US government announced retaliatory measures in March 1987 such as anti-dumping duties on the Japanese products containing Japanese chips. This tough approach by the USA eventually made the Japanese promise price increases of their chips by reducing their DRAM production (Prestowitz 1988; Tyson 1992; Borrus 1988; Tyson/Yoffie 1991; Irwin 1994).

The reduced Japanese production of 256K DRAMs and the simultaneous increase of demand from the US computer industry resulted in a serious shortage of 256K DRAMs in the world market. The consequent shortfallin the world market provided the Korean 256K DRAM producers with an important 'window of opportunity'. So Korean newcomers'first real success in the world semiconductor market wasmade possible through a window of opportunity which opened by chance. This changed the rules of the game, and the Korean newcomers have ever since been major players in this critical game. Thanks to the drastic price increase of 256K DRAMs after the end of 1987, Samsung, which had been going through financially hard times, could shed its huge deficit within a very short time (EIAK 1989; 418ff; SST 1987).[28] 1M DRAMs, which Samsung started to mass-produce in 1987, also became a major export success from 1988. Samsung chips thereby made up the majority of Korean semiconductor exports, with its share amounting to over 70% of the Korean total in 1988 (SEC 1989: 669ff). Hyundai, which had just completed its long trial-and-error process, could likewise benefit from the favourable market developments and offset its huge cumulative deficit (HEC 1994: 134; Cho, M.H. 1994). Thanks to this market success, Hyundai had become the 20th biggest MOS memory chip producer in the world as early as 1988 (HEC 1994: 139).

By these means, Korean DRAM producers became an important second-supply source for the USA, whose chip producers (with the exception of Texas Instruments and Micron Technology) had pulled out of the DRAM market by the mid 1980s.[29] So the world market dynamics provided not only the necessary window of opportunity for Korean newcomers, but also turned out to reward and positively advantage Korean firms' DRAM

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[28]According to Choi Y.R. (1994, 126), the financial situation for Samsung had actually got to a very risky point, but fortunately Samsung greatly benefited from a big boom in demand for memory chips which started from late 1987. Finally, it recovered its whole investment of the past five years within only one year and thus created room for further investment.

[29]In the second half of the 1980s especially, Korean DRAM production capacity was therefore often utilised as an OEM source for the US firms, IBM, Texas Instruments and Intel. For example in 1988, still about 70% of the Korean semiconductor products were exported under OEM agreements. This OEM-based export trend continued well into the end of the 1980s (KSIA 1995a).

strategies, helping them to establish their DRAM development trajectory on a very strong footing. The subsequent 1M DRAM boom from 1991, and the 4M DRAM boom especially during the peak period (1993), continued to place a premium upon Korean firms' DRAM strategies, allowing them to reap record profits (ICE 1995: 6-100; Cho, M.H. 1994; HEC 1994). By clearly favouring the DRAM strategy over any other product strategies, the world market dynamics contributed to the formation of the DRAM development trajectory of Korean semiconductor industry. This is clearly recognisable, for example, in the case of Goldstar, which abandoned its cautious product diversification strategy and switched over to the DRAM production path.

What role did the Korean state then play in this period? In comparison, the role of Korean state has been *only supplementary* to the already established DRAM trajectory of Korean firms, in which it promoted the co-operative development project for 4M DRAMs and 16M/64M DRAMs. Samsung's much publicised success in 256K DRAM development strengthened the position of the sectoral promoters like the Ministry of Trade and Industry. It eventually brought about a broad consensus among state authorities for the selective promotion of the semiconductor industry (Hong, S.G. 1993a); it gave rise in 1986 to the first state-promoted collaborative project for 4M DRAM development.[30] The direct impulse for the project had come, however, from the firms, which pleaded for a co-operative project equivalent to the Japanese VLSI project of the 1970s.[31] This was willingly picked up by the Korean state authorities, which felt the need to catch up with the firms' initiatives (interview with MOTIE).

The primary goal of developing 4M DRAMs was until March 1988 to be achieved through the co-operation of Samsung, Goldstar and Hyundai with co-ordination by the Electronics and Telecommunications Research Institute (ETRI), which was then under the jurisdiction of Ministry of Science and Technology (MOST). The more powerful Ministry of Trade and Industry (MTI, recently renamed MOTIE) more or less voluntarily relinquished the resources as well as the jurisdiction for this project, because it had been benchmarked by the USA as the key state actor prone to 'unfair' sectoral promotion policies and did not want to risk any further trade conflict with the USA (interview with MOTIE 1995). During the running time of the project (August 1986-March 1989), Samsung, Goldstar and Hyundai raised about half of the required funding (around US $47 million), whereas MOST and the Korean Telecommunications Corporation (KTC) paid the other half (around US $50 million) (KSIA 1994c).

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[30]The year 1986 is regarded as the turning point in the Korean state's policy towards the semiconductor industry. The state's interest had been until then limited only to the import substitution of chips with the aim of strengthened competitiveness of the electronics industry. This is clearly expressed in the amended "law for the promotion of the electronics industry" in 1981 (EIAK 1989, 166-77). This changed only with the promotion of the 4M DRAM collaborative development project. The state then came to view the promotion of the semiconductor industry no longer just as a means to strengthen the electronics industry, but as an objective to be promoted on its own (for its own purpose) (Cho, D.S. *et al.* 1994, Song, Y.J. 1995, KIET 1994).

[31]In fact, however, there is no clear evidence for Japanese VLSI project being unequivocally successful or co-operative.

Contrary to the initial plan, a genuinely co-operative R&D programme among the participating firms did not come about. A ’controlled competition system’ according to the Japanese model (Borrus 1988) could not come into existence, for two reasons. Firstly, there was too large a technological gap between Samsung, as the forerunner, and the follower firms, Hyundai and Goldstar. Samsung had already started with its own 4M DRAM development when it participated in the 4M DRAM project for financial reasons (SEC 1989: 661ff). However, it was not at all prepared to share its more advanced technological know-how with other firms (SEC 1989: 661ff; critique by HEC-employee interview 1995). Secondly, there was too strong a degree of mistrust among the participating firms, with the inferior quality of ETRI’s R&D capacity relative to that of the firms meaning that no co-operative lab within ETRI was set up to carry out genuinely collaborative work. So all of the research work was performed in individual firms' laboratories, and despite the initial plan, no exchange of researchers between participating firms took place.

Hence, instead of the intended co-operation mechanism, an enhanced competition mechanism was put into place to accelerate 4M DRAM development. This was an incentive system based upon a strong rivalry among the firms, by which the more successful firms were rewarded with more subsidised credits, while research funds for the next projects were cut for the firms which failed to meet given research objectives (Hwang/Youn 1992; Jun/Kim 1990). The project could not avoid the duplication of firms’ R&D activities,contrary to its initial plan, but it was highly effective in accelerating the development of 4M DRAMs, which were successfully developed already by February 1988 — much earlier than initially planned.

How far was then the project really useful to the firms? Samsung could have developed the 4M DRAMs without the project, but it helped to shorten the development period (interview with MOST), which is especially important as the time factor is essential in DRAM competition. Thanks to the collaborative project, Samsung’s development gap in 4M DRAMs behind the market leaders narrowed to only six months (SEC material 1995), and Samsung could already begin mass production by the end of 1989.

However, the project proved more useful to the follower firms. Hyundai and Goldstar could benefit from Samsung’s more advanced knowledge despite the lack of a real co-operation. This was because the project evaluation committee’s particular way of functioning served as an important diffusion mechanism for DRAM technology (Bae, Y.H. 1995: 125ff). The committee used to hold regular evaluation meetings on each individual firm’s progress in the following way: Samsung’s new achievement was evaluated by the evaluation committee, whose members were not only from universities and ETRI, but also from the other two participating firms, Goldstar and Hyundai. If Goldstar achieved a certain degree of progress, it would be evaluated in turn by a committee made up of members drawn from universities, ETRI and this time the other remaining firms, Samsung and Hyundai.

This mode of operation contributed to information-sharing and an active diffusion of 4M DRAM knowledge, mostly from Samsung to Goldstar and Hyundai, helping to raise their knowledge level to that of Samsung.[32] So the 4M DRAM project represents a good example of how a positive diffusion effect for DRAM technology can be produced through the *external organisational assistance* of the state. Even though the state was unable to organise a really efficient controlled competition system among the rival firms (see also Kim, H.K.'s critique 1991), it played a limited role as a catalyst for the diffusion of DRAM technology.

Nonetheless, the steering capacity of the Korean state in the second half of the 1980s was by and large limited. The state authorities adjusted themselves to the firms' own DRAM initiatives, by simply reinforcing their DRAM trajectories. The state did not greatly help to enrich the institutional capacity of the semiconductor industry beyond the existing *chaebol*-governance, as might, for example, have been done by encouraging the building of co-operative networks between the small and medium-sized semiconductor machinery producers and big chip-makers. Instead of thus keeping the entire semiconductor industry structure in sight, it restricted itself to an additive policy with a narrow product focus. In consequence, the existing DRAM trajectory and continuity of *chaebol*-governance of the industry were simply endorsed and reinforced by the state, which lacked any strategic action for building an alternative governance structure or alternative (product) development path.

The limited steering capacity of the state became all the more evident in the 1990s, as it proceeded — using the familiar, albeit increasingly ineffective, credit instrument[33] — with further collaborative 16M/64M DRAM and 256M DRAM development projects. The newly included partial promotion measures of the 1990s for big chip producers to co-operate with small and medium-sized enterprises (SMEs) have so far yielded scant results, as the existing technological gap between them is far too big for the chip producers to think of true co-operation with the SMEs, except for some low-end areas (interviews with SEC and HEC 1995). Korean chip-makers prefer to go abroad or set up joint-venture firms together with advanced foreign firms in semiconductor machinery and materials, mostly or often within their existing *chaebol*-structure; they have thus expanded their *chaebol*-governance further into these upstream industrial areas.[34] So the current tendency indicates *bifurcation* between the world market players in DRAMs and the poorly developed SMEs, which are hard to integrate into the 'Samsung system',[35] 'Hyundai system' and 'Goldstar system' (themselves sharply delimited from one another).

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[32]I owe this insight to discussions with Ham S.H. (MOTIE) and Choi Y.R. (STEPI).

[33]Compare Krasner's "institutional stickiness"-concept (1988).

[34]The examples are: Towa Korea (Samsung's joint venture with Hanyang and the Japanese company, Towa), Korea DNS (Samsung's joint venture with the Japanese company, DNS), Posco Huels (Samsung's joint venture with Huels and Posco), Samsung Corning (a Samsung subsidiary) and Goldstar's subsidiaries, Siltron and Goldstar Micronics (various newspaper articles; for details see S. Ran Kim forthcoming).

[35]I owe this expression to John Mathews (discussion 1995).

The 16M/64M DRAM project (April 1989 - March 1993) was more or less implemented according to the same principles as the 4M DRAM project. 16M DRAMs were successfully developed in 1990, and 64M DRAMs in 1992; earlier than planned.
The relatively good track record of the state's promotion of 4M DRAMs, and the sheer economic importance of DRAMs as the most important export product of the country, brought about the otherwise difficult inter-ministerial consensus for further promotion of the 256M DRAM development project (November 1993 - December 1997). This continuous promotion was by no means a matter of course, particularly given the lack of state support for ASIC development, because the inter-ministerial co-ordination was usually absent (MOST 1993: 377ff; workshop proceedings in KSIA 1994b).

However, the actual benefit from such exceptional promotion by the state is becoming more questioned now than ever before. While at least Hyundai and Goldstar could benefit from certain technological diffusion effects of the 4M DRAM project, the subsequent DRAM projects are reportedly of no real use even to these former followers, as their technological level has now become as high as Samsung's. Nor is there any further financial incentive left for Samsung and other firms. Thanks to their record profits resulting from the recent DRAM booms, they came to think that 'the small amount of the credit is not worthy for us to go through the whole bureaucratic procedure associated with those DRAM projects' (interviews with SEC, HRI, KSIA and HEC 1995). A government official who is in charge of the semiconductor promotion policy suspects that the participating firms may wish to drop out from the continuing DRAM projects, because of 'the lack of relevance to their actual development', though they 'are reluctant to say so' (interview with MOTIE 1995).

The reason why the Korean firms keep participating has much to do with the specific state-*chaebol* relationship in Korea. According to the insiders, the firms do not want to risk any direct resentment from the state authorities by pulling out from the present collaborative project. For such a 'short-sighted calculation' may result in their exclusion from any future and possibly useful state-promoted project, while their rival *chaebol* firms may be granted the preference for participation (interviews with KSIA and MOST 1995). The ever-present threat and the strong probability of other *chaebol* firms being granted a favourable treatment by the state or a privileged participation thus prevent the individual firms from withdrawing even from the present collaborative project, which may serve as a stepping stone to interesting projects in the future.

This is plausible, particularly as all *chaebol* firms with similar, horizontally diversified structures can move quickly into any area, posing a new rivalry to other *chaebol* firms in almost all areas. At the same time, the 'circle', and the numbers of *chaebol* firms as potential collaborative partners for the state, remain rather constant. This peculiar combination of strong competition and rivalry within the circle of *chaebol* actors grouped around potential favours from the state appears to work as a brake on the *chaebol* firms' pursuit of their own short-term interests. Hence the specific 'state-societal arrangement' (Hart 1992), from which the *chaebol*-governance emerged, seems to be still intact. This allows the Korean state to play the role of linchpin, holding the competing firms together, even in the hardly useful collaborative DRAM projects of little direct use. The problem is, however, that such a role becomes less and less relevant to the actual progress of the Korean semiconductor industry.

5. Summary and Future Prospects

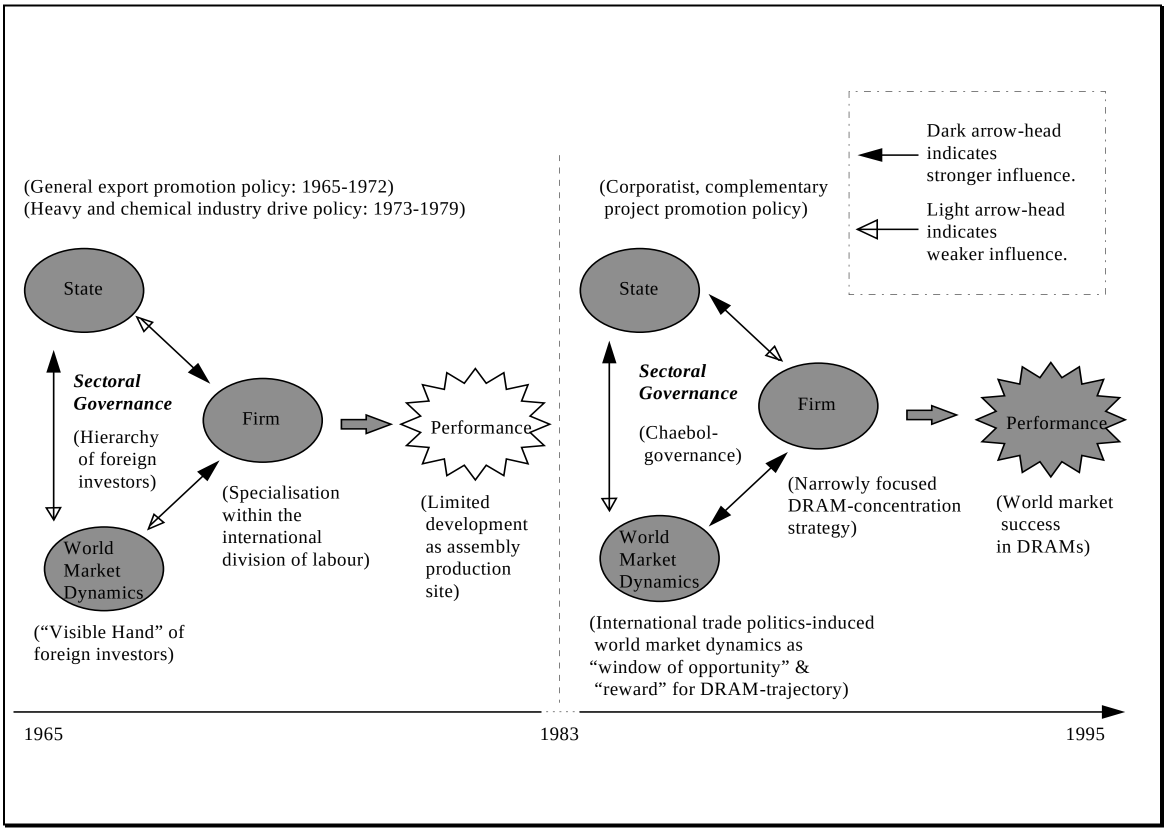
Figure 4 summarises the historical analysis of the Korean semiconductor development process so far. It shows how the three critical variables of state, market and firm, have interacted and combined to affect the growth dynamics from 1965 and 1995 (see the year axis in the figure). By focusing on the emergence and rearrangement of governance mechanisms, it seeks to understand the particular growth dynamics of the Korean semiconductor industry.

As the figure shows, there has been considerable shift in the governance structure (conceptualised here as resulting from the varying interactions of state, firm and market), as well as in the performance profile of the industry, across the two time periods (prior to and after 1983). The dotted vertical line in the figure thus divides these two time periods.

The dark and light arrow-heads in the figure indicate the shifting influences of state, firm and market. As indicated by the dark arrow-head, prior to 1983 world market dynamics exerted a major influence at both the state and firm levels. Moreover, within the Korean context the state was the dominant influence on firms. In the period after 1983 the latter relationship has been significantly altered. The actual dynamics of the relationship have been reversed and firms are now a dominant influence on state actions. Furthermore, this shifting of relationship dynamics also seems to be present at the firm-world market level. Korean firms now play a role in influencing world market dynamics, although, the latter remain a crucial factor in determining Korean firms' strategies and success, not to mention Korean state policies.

So, prior to 1983, Korean firms were merely specialised within the international division of labour, while the world market dynamics, brought about by the 'visible hand' of foreign investors, played an important role (see the left panel of the figure). The dominant form of governance was the firm-hierarchy of foreign investors, resulting in a limited development of Korea as an assembly site for foreign semiconductor firms. The state remained relatively passive, with its limited interest in a general export-promotion policy between 1965 and 1972. During the following period of the HCI-drive policy, it did not pursue any significant promotion policy for the semiconductor industry. However, the general politics of reciprocal subsidy, at their height during this HCI-drive era, were to have significant effects relating to the emergence of *chaebol*-governance after 1983.

Figure 4: Historical evolution of sectoral governance and the growth dynamics of the Korean semiconductor industry



Since 1983, the Korean semiconductor industry has attained an important growth momentum, mostly through the *chaebol*-firms' strategic initiatives. This has also been a period when all three critical variables of state, market and firm have 'pulled together' towards a new governance structure, and brought about an impressive world market success in the limited segment of DRAMs. The 'platform' for the Korean firms' leap was initially built by the state and its politics, but later on it would have to try to catch up with the private actors which were forging ahead. Its largely corporatist, complementary DRAM-project promotion policy was an addition to the narrowly focused DRAM strategies of Korean firms, but this was only limitedly successful. The world market dynamics provided an important 'window of opportunity', and its DRAM booms acted as rewards for the DRAM trajectories of Korean firms, but this depended on the preceding achievements and commitment of the *chaebol*.

The following Figure 5 summarises the arguments thus far and shows the particular sectoral functioning of the Korean national system of innovation, and its effect upon performance in the case of the semiconductor industry. The figure shows how the general properties of the Korean system of innovation have been translated (owing to its underlying *political* processes) concretely into the efficient *chaebol*-governance of the semiconductor industry, and resulted in a successful performance in DRAMs.

1) It first shows the relatively poor quality of the national system of innovation, which is characterised by the weakness of individual components (especially the R&D and education systems) and the limited extent of interactivity (mainly between state and *chaebol*).

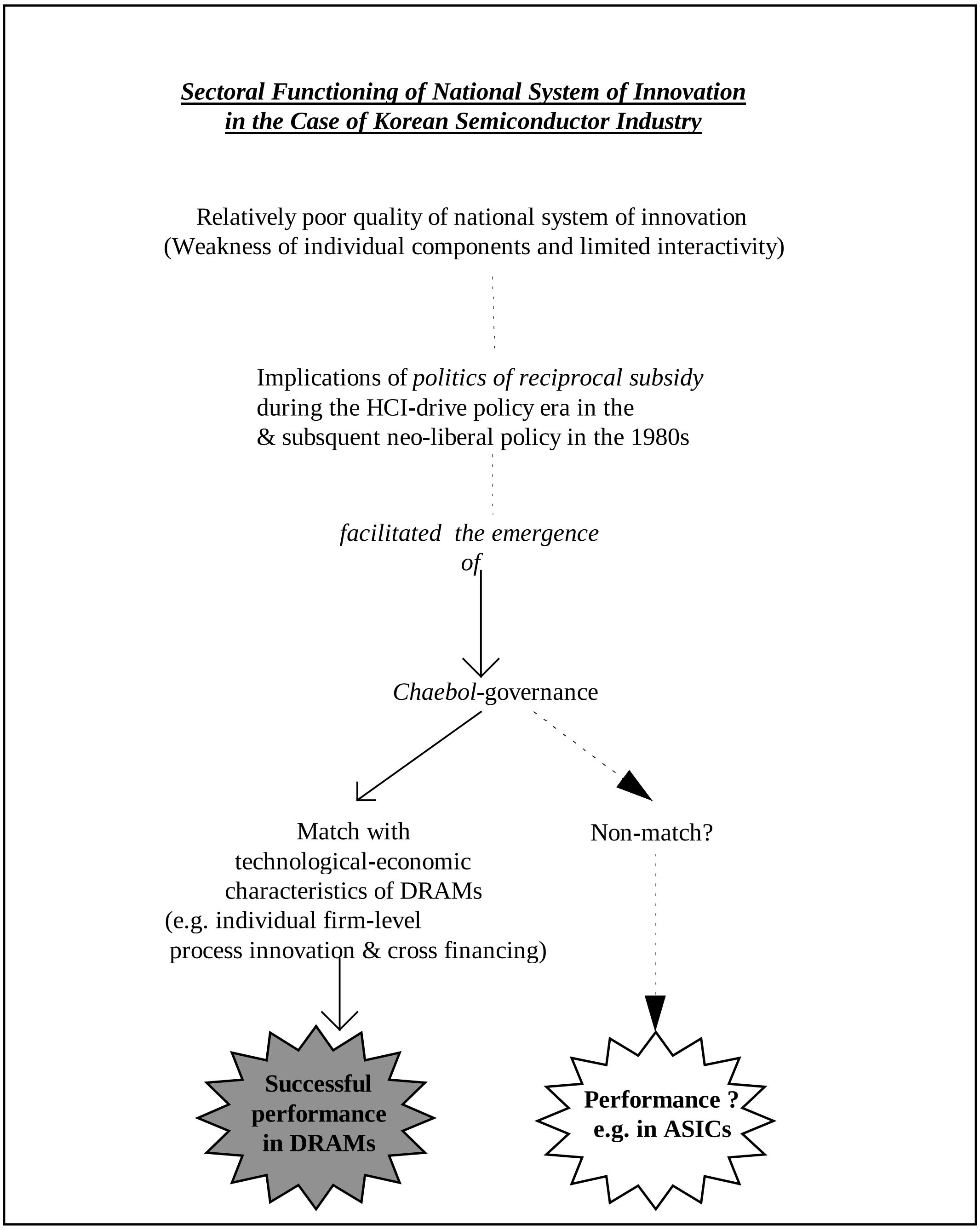
2) However, the specific socio-political processes underlying the dynamics of the Korean national system — such as the implications of the politics of reciprocal subsidy during the HCI-drive policy era in the 1970s and the subsequent neo-liberal policy in the 1980s — facilitated the emergence of *chaebol*-governance.

3) This governance structure matched particularly well with the specific technological and economic competitive conditions of DRAM chips. In this respect, the importance of incremental process innovation at the level of the individual firm (with little network-governance requirement), and the benefit of *chaebol*-level co-ordination such as the possibility of cross-financing, deserve particular mention.

4) The good match then resulted in a successful performance in DRAMs (see the bottom-left side of the diagram).

5) The figure also shows question marks and dotted arrows in regard to the extent of match and performance in ASICs on the bottom-right side of the figure, in order to highlight the *contingency* of the performance capacity of *chaebol*-governance. ASICs are gaining in importance as a technology driver for many critical technologies (see ICE 1995: 4-7, 4-39). However, it remains doubtful whether the conventional *chaebol*-governance will perform well in ASICs, which obviously have a higher network-governance requirement and greater need for incorporation of small and medium-sized user firms.

Figure 5: Sectoral functioning of the National System of Innovation in the case of the Korean Semiconductor Industry



What then are the prospects for Korean semiconductor industry's further growth dynamics?[36] How likely are the Korean semiconductor firms to achieve the second leap by diversifying successfully into non-memory chips or to extend the growth dynamics even in DRAMs, in the light of the increasing as well as changing competitive requirements?

In microprocessors, into which Korean firms want to diversify (actually more than into ASICs), the sheer demand for technological sophistication and R&D capability exceeds the present quality of R&D infrastructure and manpower which the Korean system can provide (interviewwith SEC 1995). These are likewise exceeded even in DRAMs, as Korean firms approach the technological frontier in DRAMs.[37] And this contrasts stark with the hitherto development process in which the Korean firms have been able to *internalise* (due to specific political-institutional processes) some of these basic functions of Korean system.

So the general upgrading of the R&D and educational system is urgently required, in order to sustain the growth dynamics. The problem is, however, that Korean state policies towards the semiconductor industry are too much constrained by politics and institutions to bring about the urgently required quality improvement.

Thus far, the Korean state has been unable to use taxes to improve the quality of R&D infrastructure, because of the political difficulty of increasing taxation (Ministry of Finance and Economy 1995).[38] In the light of the 'small government' initiative since the period of democratisation, very much in accordance with populist demand, a substantial increase of the small 'state quota', amounting to about 20% of GNP (OECD 1994, 131) or the much-needed increase of public contribution to the country's R&D expenditure (MOST 1993; OECD 1994) are unlikely to come about.

Owing to the lack of ministerial co-ordination, the educational system could not be upgraded to such an extent as to supply the requisite engineers and researchers, who might be able to carry out the frontier technology work. This is why Korean firms are forced to go abroad in search of the human capital and quality of R&D infrastructure in advanced countries (interviews 1995), as shown in the recent surge of massive direct investments of Korean chip producers especially in the USA, and acquisition of foreign high-tech companies (company press releases; see also Ju/Park 1995, 103ff).

Apart from the general improvement of the R&D and educational systems, the existing system of governance of the Korean semiconductor industry must be enriched in the light of the increasing need for co-operation and co-ordination beyond each individual

[36]See for a more detailed analysis: Chapter 3.3 in S. Ran Kim (forthcoming).

[37]Choi Sang-Rim (SEC), for example, makes this clear by saying: "The problem of our country is the problem of our company" (interview in: *Electronic Business Buyer*, February 1994, p. 49).

[38]This is the strongest policy instrument according to Ikenberry's classification (1986).

chaebol-system.[39] It must thereby evolve towards a system of governance capable of moving the Korean semiconductor industry towards a pattern of more diversified and balanced production.

Will the Korean national system of innovation then evolve towards a more 'networked' governance system, thus leading to a successful diversification and 'an expansion of the total system within which industrial and technological learning processes take place' (Chesnais 1986: 120)? As Lindberg *et al.* (1991: 8) emphasise, although governance mechanisms and their arrangement evolve over time, there is certainly nothing natural or inherent about that evolution.[40] Instead, it would require a lot of 'pulling together' of all three critical variables of state, market and firm, as shown in the previous Figure 4.

So far, however, it looks as if the Korean firms have become locked into the DRAM trajectory.

- The rather limited attempts to diversify out of memories have so far yielded scant results (interviews 1995; *Electronics business buyer*, 1994, February);
- World market dynamics have continued to favour Korean firms' DRAM trajectories for too long, with the fall in DRAM prices having started only very recently;
- Another important reason is the state's inability and lack of more significant strategic actions for the sake of alternative product development paths and more advanced modes of governance.

To conclude, we therefore argue that the Korean system of innovation (together with its distinctive political-institutional process) has its unique strengths as well as limitations. It was conducive to the emergence of efficient *chaebol*-governance and thus has so far worked out very well for the DRAM production and competition, but it is unlikely to work very well for other chip products where different governance and performance criteria are obviously required.

6. Conclusions and Policy Implications

The most important conclusion from the above case study would be that the performance of firms and sectors is not the direct consequence of apparently objective economic efficiency conditions. Rather it is the political-institutional processes and arrangements that play a critical role in their competitive performance.

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[39]This is necessary, not only because of ASICs, but also in the light of the increasing customisation of standard ICs (ICE 1995, 4-2).

[40]The past neglect of the healthy development of SMEs and excessive development gap between them and big Chaebol chip producers may seriously constrain the future evolution of the Korean national system of innovation towards more networked system.

The other major theoretical conclusions are as follows.

1) Concerning the concept of national system of innovation.

The Korean national system of innovation has so far proved very successful in the case of DRAMs. Its logic of sectoral functioning in the case of the Korean semiconductor industry is, however, very much a *political-institutional* one. This particular industry underlines the need for the concept of national system of innovation to highlight and to explore the political-institutional processes and governance aspects. The orthodox national system of innovation concept, that lies within a largely economistic framework, should be extended and sharpened to embrace the underlying political-institutional processes, since these are crucial for the concrete translation of the general characters of each national system into a particular sectoral form of governance and performance profile.

2) Concerning the role of Korean state and the state vs. market controversy.

Contrary to the state vs. market dualistic explanations, the Korean success in DRAMs has been neither the product of a 'Korea, Inc.' model nor of 'free' global market dynamics. Rather, it has been the result of the complex interactions the between regulations underpinning the world market, the largely corporatist state in Korea, and the *chaebol* (with their particular structural strengths for effectively mobilising and co-ordinating the necessary actors and resources at the group level). The Korean state played an important role, not through its direct targeting policy measures, but instead through its almost routinised politics of reciprocal subsidy. The state mattered indirectly and set the scene for *chaebol* companies' entry into VLSI-production, by sponsoring the *chaebol* structure. So the Korean semiconductor case indicates the importance of 'politics', not of the individual targeting policy which is so much emphasised by the proponents of state-led growth theory. Analysing the real state capacity in the sectoral development process needs inductive and historically grounded studies which pay careful attention to the specific political and institutional circumstances shaping them, as the new-institutionalist state theoreticians (e.g. Evans *et al.* 1985) emphasise. In particular, an understanding of the institutional bases such as the states' policy instruments, which are built on complex historical foundations, may provide important insights into state capacities: in the Korean case. The credit instrument provided the crucial institutional base for the 'politics of reciprocal subsidy', from which *chaebol*-governance emerged.

3) Concerning the concept of 'reciprocal subsidy'

Although Amsden (1989) made a significant contribution to the progress of the recent literature on Korean industrialisation with a more sophisticated analysis of state-market interactions, she did not fully explore the political process of reciprocal subsidy, nor its concrete effects in a particular sector. Our purpose here was therefore to explore the specific ways in which the general politics of reciprocal subsidy between the Korean state and *chaebol* worked out in this sector. Analysis of the specific pattern of market functioning and state action and its concrete sectoral effects becomes all the more necessary, if we are to address ourselves to the above-identified issue of the *contingency* (even intra-sectoral contingency) of the Korean industrial success.

4) Need for a 'broad' analysis.

Firm strategies and structures do certainly matter, but it is also necessary not to analyse them not as isolated entities, when accounting for their performances in the wider politico-economic environment of a nation, which has significant bearings upon firms' strategy and structural capacity.To understand this is as necessary as any micro-level firm analysis. In particular, the similar pattern of development and performance of all three Korean semiconductor manufacturers – despite the *initial* differences of their firm strategies – provides a supporting case for this argument.

Policy implications

What then would be the most important policy recommendations resulting from this case study for other countries? They may include a warning against any ill-judged emulation effort of Korean semiconductor success by other countries and a plea for a careful, inductive approach rather than any attempts at broad-sweeping deregulation or any narrow industrial policies aimed at a quick-fix success often advocated by proponents of the strategic trade policy argument (eg. Krugman 1986).

A policy aimed at the promotion of a sector must start with a proper understanding of the complex mechanisms underlying successful industrial performance. It will have to start inductively with a careful analysis of the local and historical contexts, in which institutions are embedded, along with all the critical variables of state, market and firm and their complex, evolutionary interactions. We argue that an appropriate policy should pay attention to the genesis and evolutionary dynamics of sectoral governance, as well as its effect upon the growth dynamics, rather than narrowly focusing upon industrial targeting policy measures or pursuing single-minded deregulation measures. The policy conclusion to be drawn from this case study will be to devise a kind of 'institutional engineering' (Hollingsworth/Streeck 1994), to promote a form of governance appropriate for the relevant industry.

Such institutional engineering will have to take stock of existing arrangements and work with them, as Streeck (1993) argues, so as to be better able to influence their evolution and their operation, and to permit firms' attempts at their own solutions rather than imposing a general blueprint on them. The need for a cautious approach arises, according to Hollingsworth and Streeck (1994: 288) particularly in the face of the inherent dynamic and constitutive unpredictability of performance criteria and institutional 'best practice' points of convergence. The Korean semiconductor industry is very much a case in point here: in the light of the different performance criteria and governance requirements of other product areas, into which Korean firms want to diversify, as well as the shifting conditions within the DRAM segment itself, a narrow dedication to a particular set of performance criteria or governance form appears to be far too risky to sustain long-term development.

NOTE

Some of the material for this paper was derived from interviews conducted by the author in February 1993 and June 1995. These are identified as Interview (*only* institution) in the text and footnotes.

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