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COMPETITIVENESS AND INDUSTRIAL STRATEGY:
THE CASE OF THE MICROELECTRONICS INDUSTRY IN THE REPUBLIC
OF KOREA AND BRAZIL

By

MARC MEHDI TASLIMI, B.A.

A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfillment of
the requirements for the degree of

(Master of Arts)

Department of Political Science .

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Ottawa, Ontario
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COMPETITIVENESS AND INDUSTRIAL STRATEGY:
A CASE STUDY OF THE MICROELECTRONICS INDUSTRY IN THE REPUBLIC OF
KOREA AND BRAZIL

submitted by
Mark Taslimi, B.A.

in partial fulfilment of the requirements
for the degree of Master of Arts

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ABSTRACT

The phenomenal evolution and pervasive nature of microelectronics technology has made it a force on par with the industrial revolution in transforming the nature of economic development and thereby the basis of international competition amongst nations.

In the ensuing pages the experience of two newly industrializing countries, namely South Korea and Brazil, in microelectronics will be examined within a comparative framework. The reference point for and the measure of the study will be the nature of international competition as determined by the essence and pace of global technological change characterizing the industry.

The purpose of this undertaking is to explore the hypothesis that technological nationalism, as practiced by Brazil, is not compatible with the development of a global high technology industry. Doing so requires a global outlook, as practiced by Korea, which views technological interdependence as key to the development of a globally competitive high technology industry.

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INTRODUCTION

The acquisition of high technology and in particular microelectronic technology has become the new Holy Grail of international competition. The phenomenal evolution of microelectronics over the last two decades has approximated a revolutionary force with social, technical and economic implications, paralleling the industrial revolution. It shares with the first industrial revolution some major characteristics such as rapid technological change often accompanied by the growth of totally new industries, major investment in expectation of rapid growth due to new technologies and the increasing importance of innovation as the central determinant of international competitiveness and economic growth. Rapid change in the core technology itself (i.e., microelectronics) combined with the spread of the technology throughout the economy confers upon the technology a heartland character. The Heartland nature of microelectronics technology has not only resulted in transforming the products we consume but the production process itself across a broad range of sectors. In doing so it has wrought technical and economic changes that undoubtedly will continue to alter profoundly the nature of international competition and thus the global context within which the developing world pursues its development objectives.

Developing countries need to commit a critical mass of human and capital resources to microelectronics development in order to exploit the benefits of the technology. Given the pervasive nature of microelectronics technology

developing countries that fail to formulate an active strategy, as opposed to passive reaction or inaction, run the risk of facing an increasingly bleak future characterized by the widening of the technological gap between them and the industrialized countries. This will ultimately result in technological stagnation and in yet another dimension of dependence.¹

Unfortunately, the majority of developing countries have as yet failed to formulate a coherent policy and an adequate resource base that would enable them to participate in the global race in this new technology, the outcome of which will play a critical role in determining a nation's position in the world economy for the next century. The exception is a handful of newly industrializing countries such as Brazil, Mexico, Taiwan, India, Singapore, and South Korea. Amongst these countries, two, Brazil and South Korea, are of notable interest in the remarkable progress they have made in acquiring technological capability in microelectronics.

The aim of this thesis is to undertake a comparative study of the development of the microelectronics industry in Brazil and South Korea [hereafter Korea] dealing primarily with the computer and semiconductor sectors. The purpose of such a study would be to identify the differences and similarities in the process of the development of the microelectronics industries in Brazil and Korea as the experience of the two countries varies considerably. This would allow us to assess the reasons for, and the efficacy of, the different patterns of state intervention exercised by each country with respect to three interrelated factors: 1) the global pace of technological change characterizing the industry, 2) the nature of the competition in the industry as dictated by the pace of technological change and 3) the nature of demand as given by domestic market conditions and the export propensity of the industry. The latter figures

prominently in our assessment due to, as shall be seen, the correlation between the size and nature of the market and innovative capabilities and scale economies in R&D and production.²

The difference in the two strategies pursued and the degree of success achieved by each nation in terms of competitive capability, as given by the ability to internalize key assets such as knowledge, skills, etc., and successfully commercialize them, stems primarily from how each has defined high technology.³ In turn, how high technology is defined depends to a large extent upon the role of the state, as given by historical ideological, political and economic factors, and the overall industrial strategy pursued by the state. As a result of different national circumstances Brazil has pursued the path of import substitution while Korea has opted for an outward oriented strategy combining elements of both export promotion and import substitution. In both cases the industrial strategy pursued has had a decisive effect on the evolution of their respective microelectronics industries.

In line with its strategy of import substitution Brazil has tended to define high technology in terms of the technical mastery of sophisticated products with the objective of technological self-sufficiency. Consequently Brazil's quest for technological capability in the field of microelectronics, which formally got underway in the early 1970s, has been heavily oriented towards import substitution through market reserve policies. The primary vehicle employed for the implementation of this strategy has been state owned enterprises and agencies heavily staffed by nationalist technocrats and dominated by their ideological outlook. The latter, along with the military motivated by national security concerns, defined not merely in terms of national defense but in terms of economic and political security as well, have been the principals involved in

the formulation and implementation of Brazil's strategy in regard to microelectronics.

Korea, by contrast, has defined high technology in terms of broad competitiveness or more specifically in terms of enhancing value added based on improved manufacturing, management and marketing techniques. Accordingly, in its quest for technological capability in microelectronics, which began ostensibly in the early 1980s although this can be dated earlier, taking into account Korea's experience as an OEM [Original Equipment Manufacturer], Korea placed less emphasis on technological self-sufficiency and was thus much more open to the importation and adaptation of foreign technology. By thinking more in terms of overall competitiveness Korea has paid more attention to end user requirements, demand conditions and hence marketing techniques which have enabled it to make substantial inroads into export markets. Indeed, much of Korea's informatics and consumer electronics industries are export oriented. Brazil on the other hand has placed little emphasis on economic efficiency, on demand conditions and marketing techniques and consequently performed poorly not only in respect to exports but in assessing the requirements and conditions of the home market. In the area of informatics, for instance, Brazil has cultivated customers almost exclusively in the domestic banking sector, which also financially controls the largest computer firms.

The hypothesis which we shall set out to explore is that Brazil's failure to view microelectronics in terms of overall competitiveness has resulted in the retardation of its comparative advantage and threatened the industry's future sustenance on a globally competitive level. Conversely, Korea's tendency to view microelectronics in terms of overall competitiveness has enabled it to enhance its comparative advantage and thus helped to ensure the future growth of an

industry which is of vital importance to the economic growth and development objectives of every nation.

In carrying out the defense of this hypothesis we shall be primarily addressing the following issues: 1) the nature and pace of technological change characterizing the industry; 2) the nature of competition in the industry as determined by technological change; 3) the role played by corporations and governments in the process of technological change and competition; and, 4) demand conditions in the development of competitive ability.

Within the context of these larger issues we shall discuss the role of technology transfer. The relation between industrial regimes and the acquisition of technological capability shall also be discussed. As our case studies shall demonstrate the relation is very real and figures prominently in understanding the strategies pursued by Korea and Brazil in regard to the microelectronics industry and in the assessment of the strategies.

In regard to a theoretical framework to guide us in our inquiry, as set out above, the pickings are slim. And what little theory there is, is not well suited to our needs. The reason for this theoretical inadequacy is that the development of technological capability is a complex and extended process and the variables involved do not lend themselves readily to precise measurement and definition. As such we shall have to utilize different theories and analytical tools as the circumstances warrant. The theories that we shall be resorting to shall include socio-political theories dealing with the state (e.g., structural Marxism), economic theories such as those concerned with product cycles, technological gaps and economies of scale and conceptual frameworks dealing with the nature of competitiveness and the role of technology transfer. These theories shall be brought to bear within the framework of a comparative methodology comparing

and contrasting institutional, macro-economic, technological and political factors relating to the microelectronics industry in Korea and Brazil.

In carrying out the task set out before us we hope to gain a better understanding of the complex and dynamic process surrounding the development of microelectronics industry in Korea and Brazil. We do so in the hopes that it may serve in some way as a basis for inquiries of a similar nature of other developing countries.

Organization

The thesis is divided into two parts. Part one concentrates on the development of the empirical and conceptual foundation of the work. Chapter One presents a brief survey of the technical dimension of the microelectronics industry in attempt to familiarize the reader with the technical intricacies of the technology and the production process.

Chapter Two examines the characteristics of the microelectronics industry from a global perspective as given by the nature and pace of technological change. The goal here is to discern the salient elements which have been responsible for steering and shaping the evolution of the industry and defining the nature of competition and competitiveness. This shall serve as the framework for the assessment of the different strategies pursued by Brazil and Korea in their quest for capabilities in microelectronics.

What competitiveness is and how corporate strategies and state policies affect it with respect to the microelectronics industry is the subject of Chapter Three. In regard to corporate strategies emphasis is placed on globalization and vertical integration as dictated by the pace and nature of technological change characterizing the industry. In regard to the state's role, industrial strategy and

technology transfer are emphasized due to their importance in the development of competitive capabilities.

Having established the empirical and conceptual framework, part two focuses on the core of this study: case studies examining the development of the microelectronics industry in Korea and Brazil. To understand the basis of why the strategies pursued by each nation in developing microelectronics capability differ it is essential to first examine institutional differences. Therefore, Chapter Four examines the evolution and role of the state with respect to industrial policy in the two nations.

Chapter Five examines the development of the microelectronics industry in the two nations. In doing so it attempts to describe and assess the efficacy of each nations strategy with respect to the empirical and conceptual framework set out in part one.

Finally Chapter Six summarizes and assesses the different patterns of state intervention exercised by each nation in the microelectronics industry. In so doing it shall attempt to shed some light on the choices made by each nation and attempt to draw lessons that will, it is hoped, be of value to studies of other developing countries with ambitions in microelectronics.

NOTES (Introduction)

1. For an authoritative account of the microelectronics industry and its implications for the developing countries see: S.C. Bhanagar and Bjorn N. Anderson eds, Information Technology in Developing Countries (Amsterdam: North-Holland Publishing Company, 1990) and Mohan Munasinghe, Computers and Informatics in Developing Countries (London: Butterworths, 1989).

2. In speaking of the correlation between demand conditions and innovative capacities I draw on the work of Michael Porter, The Competitive Advantage of Nations (New York: The Free Press, 1990), 86-130. For Porter demand conditions are one of the major determinants of national competitive advantage.

3. This and the following two paragraphs dealing with the different strategies pursued by Korea and Brazil in regard to industrial/technological development and the consequences thereof draw on the work of Henry Nau, "National Policies For High Technology Development and Trade: An International and Comparative Assessment," in National Policies For Developing High Technology Industries, eds. Francis W. Rushing and Carole Ganz Brown (Boulder: Westview Press, 1986) 9-31.

PART

ONE

Empirical and Conceptual Framework

CHAPTER ONE

Microelectronics: The Technical Dimension

Introduction

In order to understand the structure of the microelectronics industry it is imperative that we first take a closer look at the underlying technology. This chapter shall recount the evolution of microelectronics technology,⁴ survey the present day technological landscape consider the trends and future of microelectronics technology. It is not our intention however to provide a technical treatise on the state of the technology. Rather, our purpose is to provide a sufficient background on the technology concerned so as to enable the non-expert reader to comprehend more fully the implications for the economics, strategy and organization of the firms and countries concerned.

The Semiconductor

The dawn of the microelectronics revolution came about in 1947 with the invention of the transistor at Bell Laboratories.⁵ The transistor, a semiconductor device that can either amplify or switch signals, replaced the large, power hungry vacuum tube. A transistor that amplifies current is called a linear or analog device because its output varies continuously as a given function of its

input. A transistor that switches signals is called a digital device; rather than smoothly amplifying a signal a digital device turns the flow of current on or off in response to a signal. This on or off quality is based on binary notation, usually characterized by the numbers one (on) and zero (off). It is this very quality which distinguishes digital devices from analog devices and enables them to perform logic operations within a computer. Since radio broadcasting is at present based on analog technology- in which an analog transmitter duplicates the pattern of the vibrations picked up by the microphone by modulating an electromagnetic waves amplitude (AM) or its frequency (FM)- analog devices dominate a good portion of the consumer electronics market. However, with the introduction of the CD (Compact Disk) and the dawning of digital audio broadcasting technology (DAB), both of which are based on digital technology, the market for analog devices will increasingly and rapidly dwindle. In both CD and DAB sound is encoded as a series of numbers based on the binary code. The digital receiver picks up the numbers, decodes them and presents the results to the speaker, which reproduces them as audible sound.⁶

The semiconductors manufactured in the 1950s were what are called discrete devices. That is, each of the components is manufactured separately and then assembled into a circuit by wiring each of the components together with metallic conductors. In 1958, however, research at Texas Instruments and Fairchild's resulted in the invention of the monolithic integrated circuit (IC). The major difference is that with ICs all the elements and their interconnections are fabricated on a single semiconductor, commonly referred to as a chip, in a single series of operations.

Integrated circuits are essentially of two types, bipolar and MOS. In bipolar technology conduction occurs through the movement of both polarities

(electrons and holes) and control is achieved through electric signals. In MOS technology, on the other hand, conduction is based on unipolarity: conduction occurs through the movement of either electrons or holes and control occurs through voltage. While bipolar ICs have the advantage of possessing speed, MOS ICs permit lower power consumption, greater density in the packing of elements, higher yields in production and therefore lower cost per active element than do bipolar ICs. It is no surprise therefore that MOS ICs predominate in the microelectronics industry.

The density or scale of integration of ICs has multiplied dramatically and regularly since their invention. Since their invention IC production has doubled annually. The density of an IC is usually characterized by its scale of integration (the number of parts that form the circuits). The greater the density, the greater the complexity. Small scale integration (SSI) refers to ICs with fewer than 100 parts. Medium scale integration refers to ICs with between 100 and 999 elements. More complex ICs are most often used in computers and can be described by the number of bits that can be stored in a memory circuit of similar complexity. Large scale integration (LSI) denotes circuits of complexity up to 16 kilobits of memory. Very large scale integration (VLSI) describes devices capable of between 16 kilobits and one megabit of memory. Finally there is extra large scale integration (ELSI) which refers to circuits containing more than one megabit of memory. The dominant trend in microelectronics over the past two decades has been the rapid, continuous reduction in circuit size and a corresponding increase in chip density. The implications of this trend have been a steady rise in the amount of information that can be processed by ICs and a simultaneous decrease in the amount of time required to do this by several orders of magnitude.

ICs can also be categorized according to their degree of customization, standard, custom, and semi-custom types. Standard devices are produced in large volumes for a wide range of applications: they have a low price and a high degree of reliability, however, they do not use the space on the substrate in the most efficient way. In contrast, custom ICs are produced in small volume for specific uses, according to users' specifications. Although they have a higher price and a longer turnaround time than standard devices they make the most efficient use of the substrate's space. Semi-custom ICs possess characteristics of both standard and custom devices and more. Like standard devices they have a generic structure which means that they can be produced in large volume, at low price, with a high reliability and a rapid turnaround time. At the same time they can be customized either by the producer or by the user. Thus they are able to meet the users specific specifications and requirements. The latter quality has been responsible for the substantial increase in the semi-custom (also known as application specific ICs or ASICs) market in comparison with the standard and custom market.

ICs can be further classified according to logic families: memories, processors and computers.

Memories are ICs which serve as a device for storing digital information. Both storage (write) and retrieval (read) operations are completely under electronic control. Their memory capacity is measured in binary units of information or bits. There are essentially two types of memories, ROM (read only memory) and RAM (random access memory). In ROM ICs information is placed in the storage array at the time of manufacture and cannot be changed thereafter. Programmable ROMs (PROM) however can be programmed after manufacture and then cannot be changed. ROMs are often used in such devices

as calculators in which the control programs are usually permanently stored. Information in ROM ICs is not lost when external power is removed. The information stored in RAM ICs however can be programmed after manufacture and continuously changed thereafter. RAMs are of two types: static (SRAM) and dynamic (DRAM). SRAMs maintain their contents whereas DRAMs must be continuously refreshed because their content decays over time due to the leakage of current. As such, information that is to be retained must be saved after every read operation.

A processor is a computer's central processing unit (CPU) contained on a single chip. The function of a processor is to receive data in the form of strings of binary digits, to store the data for later processing, to perform arithmetic and logic operations on the data in accordance with previously stored instructions and to deliver the results to the user through an output mechanism such as a monitor. Microprocessors are classified according to the length of words they process (4-bit, 8-bit, 16-bit, and the most recent 32-bit). The invention of the 4-bit microprocessor by Intel in 1972 marked a fundamental technological breakthrough and made possible the move away from large mainframes to cheaper and flexible microcomputers. For the first time it was possible to incorporate all of the elements of a computer on a single chip. Processors and memories together make up computers.

Semiconductors: The Production Process

The manufacture of semiconductor ICs falls essentially into four stages: the mask design, the crystal growth and slice preparation, the fabrication of the

wafer, the assembly and the final testing. The four stages can be and usually are physically separated from one another. Indeed, one or more of the stages can be subcontracted out. The mask design stage begins with the design of the circuit, which is carried out with the aid of a computer in order to ensure the most space efficient layout of the circuit elements. The resulting layout is then used to prepare a set of photo masks each containing the pattern for a single circuit layer. The initial design work is often thought of as part of the R&D process. The amount of R&D required, in terms of both time and capital, to complete the task of circuit design and layout varies considerably according to the nature of the circuit. The most difficult circuits to design are processors. The design and layout of such devices can take several years and involve a great deal of R&D effort and expenditure. This is especially so as the race for building ever faster computers, such as the teraflop, a computer capable of running more than a trillion mathematical calculations each second, heats up requiring ever more complex and faster processors. Other devices such as static memories with a largely repetitive pattern, can be designed and laid out more quickly, in some cases in only a few months.

The second stage, wafer fabrication, begins with the sawing of a long single crystal of silicon into thin slices to obtain the silicon wafers that serve as substrates for the circuits. These are then polished, cleaned and oxidized in preparation for the first patterning process through lithographic processing techniques, in which the photomask pattern is photographed on to the wafer.

The third stage, assembly, involves the assembling of the chips into usable packaged devices. Each chip is mounted on to a base and the contacts on the chip are connected to the external connections of the base with metal wire, usually gold.

The fourth and final stage is concerned with the testing of the semiconductor device. At this stage the device undergoes a number of electrical and mechanical tests. The complexity of this process requires the use of computer controlled equipment. As in any production process, no matter how carefully the process is carried out, there are bound to be defects. Each of the four stages of the production process has different yields, which represent the ratio of usable chips to the maximum possible. The yield is the most important factor in determining the unit manufacturing costs of ICs. While it depends on many factors perhaps the most important is production experience. As a general rule, in the industry, unit cost tends to fall by approximately 30 percent as production volume doubles, a relationship often referred to as the learning curve. In order to speed up the learning process firms often resort to strategies such as penetration pricing- pricing below average cost- so as to increase market share and volume and thus achieve greater learning economies. The assembly phase, however, does not give itself so readily to learning or scale economies. Traditionally the most labour intensive stage of production process, it has often been carried out in offshore assembly sites taking advantage of cheap and abundant labour. However, as the assembly stage becomes increasingly more automated such sites will gradually lose their advantage.

Each of the stages in the manufacturing process has varying needs in terms of capital investment and labour skills (Figure 1.1). The R&D, or design stage, along with the mask making and wafer fabrication stage are the most capital and skill intensive. As the assembly and final testing stage become increasingly more automated and thus more prone to economies of scale they too shall become increasingly intense in their use of capital and skilled labour.

Figure 1.1 Semiconductor Labour Processes

Labour Processes	Capital Intensity	Skill Requirement		
		Scientific\ Engineering	Technical	Semi\ unskilled manual
Research & Development	+	+	-	-
Mask Making	+	+	+	-
Wafer Fabrication	+	+	+	+/-
Assembly	+/-1	-	+/-	+
Final Testing	+	+/-	+	+/-

Note: (1) Where automation has taken place

Source: Jeffrey Henderson, The Globalization of High Technology Production, 32.

Microelectronics: Semiconductors and the Electronics Complex

The applicability of semiconductor technology goes far beyond the electronics industry. From process to product, from design to manufacture this technology has permeated every field from aircraft to automobiles. Its most pervasive effect, however, has been in the area of computers and consumer electronics, the two main areas under investigation in this thesis.

In the first years of IC production the military and aerospace market accounted for virtually all demand. In the years since this market has withered away accounting for a mere 9 percent of demand in 1985. While the military and aerospace sector's needs played a significant role in the early development and diffusion of microelectronics technology, today this role belongs to that of the computer and consumer electronics sector. For instance, in the recent Persian Gulf war much of the high tech equipment that gave the allied forces a decisive advantage was adapted from consumer electronics technology used in such products as camcorders. As shown in table 1 in 1985 over two-thirds of world

demand for ICs was generated by these two sectors.

The significance of computers and consumer electronics in terms of their share of semiconductor devices and their technological potential bestows upon them a strategic disposition in the competitive advantage of nations. By virtue of this disposition they require closer examination.

Table 1.1 World Demand For Integrated Circuits By End Use Market, 1962-85, As A Percentage.

<u>End use</u>	<u>1962</u>	<u>1970</u>	<u>1976</u>	<u>1980</u>	<u>1984</u>	<u>1985</u>
Computer	0	64	45	44	39	36
Telecommunications	0	5	10	10	11	15
Industrial	0	-	-	10	13	10
Military & Aerospace	100	-	-	8	7	9
Consumer	0	5	15	23	30	36

Source: Langlois et al, 33.

Computers

The development of the transistor, almost 43 years ago, was to provide the fuel for the launching of a new era in information technology. The vehicle which was to make the launch possible was none other than the digital computer.

The advent almost simultaneously of the stored-program digital computer provided a large potential market for the transistor. The synergy between a new component and a new application generated an explosive growth of both. The computer was the ideal market for the transistor and for the solid-state integrated circuits the transistor spawned, a much larger market than could have been provided by the traditional applications of electronics in communications. The reason is that digital systems require very large numbers of active circuits compared with systems having analogue amplification, such as radios.⁷

The tremendous potential of computers was not realized immediately. The first generation of computers were large, cumbersome machines with the capability of doing calculations that can today be carried out using a small hand held calculator. However, as the ability for miniaturization of electrical components increased, motivated by military and space agency needs, concomitantly with the sophistication of the components, the market for computers also increased as they developed into multipurpose systems with a large and highly diversified range of applications.

Between 1960 and 1978 the value of installed computers increased from \$112.7 billion to \$424 billion. In 1990 this figure was expected to climb over \$1 trillion.⁸ In 1985 fully 36 percent of world demand for ICs was for computers (Table 1.1). While the share of IC demand by computers has fallen since 1970 it is still over one-third of the total. In 1984, on average, 10 to 12 percent of a computer's total cost was the cost of its ICs. This is somewhat higher than the 8 percent average cost for other electronics systems products.⁹

Consumer Electronics

With the introduction of microelectronics technology to the consumer electronics industry a once mature industry has been rejuvenated into a dynamic and highly competitive industry. The rejuvenation has been characterized by the burgeoning demand for the proliferation of new products based on microelectronics. Without the advent of microelectronics, products such as compact disc players, digital radio, camcorders, fax machines and satellite dishes, many of which have become an integral part, either directly or indirectly, of our lives, would not have been possible.

The world demand for ICs by the consumer electronics sector has risen steadily over the years. From a low of 5 percent in 1970 it has increased by more than 7 fold to 36 percent of the world demand for ICs (table 1.1) and this figure is expected to rise or at least remain constant in the near future. It should once again be pointed out that while much of the consumer electronics industry relies on the use of analog, or alternatively linear, devices this is expected to change with the diffusion and increased sophistication of digital technology.

Conclusion

The purpose of this chapter has been to familiarize the reader with the technical intricacies of microelectronics technology and the production process by undertaking a brief survey of the technical dimension of the industry.

The chapter focused on the semiconductor, computer and to a lesser extent the consumer electronics sectors. The emphasis on the semiconductor sector stems from the fact that this sector lies at the heart of the microelectronics complex. As shall be seen in the chapters to come an understanding of this sector is vital to understanding the structural changes characterizing the industry (discussed in Chapters Two and Three) and the implication of these changes for the microelectronics industry in Brazil and Korea (discussed in Chapter Five).

Out of the electronics complex based on semiconductor technology two sectors, computers and consumer electronics were singled out for discussion. The choice was based on the significance of these two sectors in terms of their share of semiconductor devices and their technological and trade potential which as noted earlier bestows upon them a strategic disposition in the

competitive advantage of nations. By virtue of this fact they, particularly the computer sector, along with the semiconductor sector are the focus of this study.

NOTES (Chapter One)

4. At the heart of microelectronics technology lies the semiconductor. A semiconductor as the name implies is a material having a resistivity in the range between conductors and insulators and possessing a negative temperature coefficient of resistance. The conductivity increases not only with temperature but is also affected very considerably by the presence of impurities in the crystal lattice. With the employment of a doping process the addition of controlled amount of impurities changes a semiconductor from a poor to a good conductor of electricity. Devices employing such semiconductors are able to amplify or switch electronic signals. It is this very ability that lies at the heart of microelectronics technology, from computers to digital broadcasting.

5. The following pages on the nature of microelectronics technology and the production process draw extensively on the work of various authors in: "Microelectronics," Scientific America, vol. 237, no. 3 September 1977, 63.

6. The Globe and Mail, July 13, 1991, C3.

7. Robert N. Noyce, "Microelectronics," Scientific America, September 1977, 63.

8. Cees J. Hamelink, The Technology Gamble, (Norwood: New Jersey: Ablex Publishing, 1988), 6.

9. Richard Langlois et al., Microelectronics: An Industry in Transition (Boston: Unwin Hyman, 1988), 32.

CHAPTER TWO

The Global Microelectronics Industry

Introduction

The Global Microelectronics Industry is in a period of rapid transition. Established trade and production patterns are being eroded with the advent of revolutionary new technologies. This, in addition to rising competitiveness has necessitated intensified R&D spending and capital expenditures subject to substantial economies of scale and scope. The cumulation of these factors has clearly favored large vertically integrated firms with a diversified product base. Thus, small firms which have traditionally been one of the industry's primary sources of innovative juices are being squeezed dry as the industry takes on an ever more highly oligopolistic character. This latter quality has also resulted in creating increasingly higher barriers to entry, making it ever more difficult for developing countries to obtain membership in the high tech league.

In order to understand these developments we shall briefly review the technological forces which are shaping and driving the international microelectronics industry. This shall serve as a backdrop for Chapter Three's examination of the nature and role of state and corporate policies in the transformation of the global microelectronics industry, and lay the basis for Chapter Five's assessment of the different patterns of state intervention in the development of the microelectronics industry in Korea and Brazil.

The Microelectronics Industry: Producers

The informatics industry is comprised of a vast industrial complex resembling an inverted pyramid in structure. At the base are the upstream industries which produce the materials and the equipment required to produce semiconductors. At mid-level there are the midstream industries that manufacture semiconductors. Finally at the base of the inverted pyramid are the downstream industries- computers, telecommunications, defense, etc.- that are dependent on the former two for inputs in producing their final products. This vast complex forms an integrated fabric, the weakening of any part thereof will send ripples throughout the entire structure. In this section my examination shall be confined to the semiconductor and to a lesser extent the computer sectors of the informatics industry.

Semiconductors

With an annual average growth rate of about 16 percent since the late 1950s the semiconductor industry is one of the fastest growing manufacturing industries. Taking into account price declines however, the real growth rate of the industry has been much faster, averaging an annual growth rate of 25 percent.¹⁰ The price declines can be ascribed to primarily two factors. One, as firms have moved up their learning curves and become more experienced in production their average unit costs expressed as a function of output have declined. And two, the increased sophistication of ICs, if expressed in terms of price per function, is another source of price decline.

In 1984 global semiconductor production amounted to 34 billion dollars. Between 1986 and 1991 the semiconductor industry grew between 12 and 13

percent. By 1991 total semiconductor production totaled approximately \$50 billion. In terms of national share the U.S. leads the pack. In 1986 it accounted for approximately 50 percent of global production. While Japan came in second with a 38 percent share it should be noted that its production is growing much faster than that of the U.S. Between 1978 and 1986 the Japanese production grew at the rate of 23 percent compared to 14 percent for the U.S.¹¹ Thus, it may be only a matter of time before the Japanese catch up or even surpass U.S. production. Western Europe accounted for 10 percent, a substantial part of this is produced by subsidiaries of American firms.

The rest of the world, excluding the Soviet Union and Eastern Europe accounted for only 1 percent of global production of semiconductors in 1986. Much of this took place in the first and second tier Asian NICs. Of these Korea was by far the largest producer. The production of the Latin American NICs accounted for an insignificant share of global production. Moreover, the output of the largest producer, Brazil, is highly inward oriented to the supply of the domestic market. We shall delay further discussion of Korea and Brazil till Part Two, where a much more detailed discussion shall be provided.

Computers

With particular regard to the computer industry, the most striking development here has been the emergence of the microcomputer, made possible by the advent of the microprocessor, and the phenomenal growth in demand for them. Priced at a fraction of mainframes, these systems have benefited to such an extent from improvements in component technology that it has become increasingly difficult to distinguish between them and the more powerful mini and mainframe computers. The world market for microcomputers in 1983 was

estimated at \$11 billion, \$33 billion in 1987 and \$50 billion in 1990.¹²

In terms of global industry structure the U.S. once again tops the list with one firm alone, IBM, controlling approximately 70 percent of the world market for mainframes and between 30 to 40 percent for virtually every other product segment and industry sector in which it is involved. Japan, however, which comes in second has begun to launch a broad based challenge to U.S. supremacy and is gaining ground in this highly competitive battle for market share. In contrast, European firms while possessing a strong domestic presence are not likely to pose any threat to the U.S. or Japanese positions, at least not in the near future. However, with the unification of the European market in 1992, resulting in the creation of the single largest market in the world, and concomitantly the increased integration of R&D efforts in such projects as ESPRIT, Europe shall play an increasingly crucial role in the global microelectronics industry, especially in regard to the developing countries in terms of an export market and source of technology.

The Size factor and Competitiveness

A key reason often cited for the overall U.S. lead in microelectronics production, particularly in the semiconductor sector, is the structurally diverse character of the U.S. industry. While it was the large established electronic firms, such as AT&T, Texas instruments, and IBM, that pioneered the development of the microelectronics industry, further innovations in process and design technology enabled the emergence of smaller independent firms specializing in the manufacture of semiconductors- merchants. In the 1980s the merchant firms accounted for up to two-thirds of U.S. semiconductor production.¹³

The small size and dedicated nature of these firms combined with their

enterprising entrepreneurship has afforded them with a degree of creative competitive dynamism which many industry analysts have ascribed as being an important factor underlying U.S. leadership in microelectronics technologies as a whole.¹⁴ Indeed, these small firms have accounted for a large proportion of the more recent technological breakthroughs in microelectronics.

However, since the early 1980s the U.S. lead in microelectronics has been steadily eroding. While a number of factors have contributed to this decline, the primary cause can be traced to the rapid pace of technological progress¹⁵ in microelectronics in light of the structure of the U.S. industry. The rapid pace of technological progress has had the effect of steepening learning curves while at the same time shortening product life cycles and sending the price of new components spiralling downwards. The combined result has necessitated intensified R&D effort and increased capital outlays by firms and governments in order to maintain competitiveness.

Moreover, while the demand for semiconductors has grown dramatically over the last three to four decades and is expected to continue its growth in the years to come, it has shown a tendency to be highly volatile. This is reflected in the highly cyclical nature of profits and capacity utilization in the industry, as exemplified by the U.S. industry in Figures 2.1 and 2.2.

Once again the cause of this is partly due to the pace of technological progress. As the pace has speeded up the market has tended to lag behind, unable to absorb the new technologies as fast as they come on line. At the present pace for instance, it is predicted that 'By 1995 all computer and information systems being installed now will have become obsolete¹⁶.' Thus, technological progress which has been the primary driving force of the microelectronics industry may very well turn out to be its Achilles heel also.

Figure 2.1

**PROFITABILITY OF SEMICONDUCTOR
INDUSTRY COMPARED TO ELECTRONICS
AND ALL MANUFACTURING**

Source: Howell, 24

Figure 2.2

**SEMICONDUCTOR INDUSTRY CAPACITY
UTILIZATION COMPARED TO ALL
MANUFACTURING
(Percent Utilization)**

Source: Howell, 25.

The above factors have combined to bring about the oligopolization of the global microelectronics industry. Small firms everywhere, lacking the ability to muster the financial resources to keep up with spiralling R&D and capital outlays, are finding it increasingly difficult to compete and, indeed, to survive. Competitiveness is more and more being equated with vertical integration, both backward and forward into upstream and downstream products, a diversified product base allowing for economies of scope¹⁷ and the ability to access large amounts of capital and to sustain short term losses. However, even large firms are finding it difficult to go it alone and are increasingly resorting to strategic alliances involving technology swaps and in rare cases to undertaking joint R&D efforts. Perhaps the most notable example of this form of alliance in recent history is the consortium formed by U.S. semiconductor producers and their upstream suppliers, SEMATECH, which is intended to reverse the erosion of the U.S. position in semiconductor manufacturing by developing, proving, and demonstrating state-of-the-art semiconductor manufacturing process, tools and materials.¹⁸ Another example is the decision taken by IBM and Apple Computers, the two main arch rivals of the U.S. computer industry, to exchange software and hardware design computer technology and to selectively collaborate on the development of new technologies. It is unlikely that such alliances reflect a move toward greater global cooperation. Rather they should be viewed in the context of heightened competition in which technologies are increasingly being used as bargaining chips.

In contrast to the U.S. industry, the European, Japanese and Korean microelectronics industries are dominated by large, vertically integrated firms, and in the case of the latter two, with a diversified product base. As such, given the nature of technological change in the industry, upon which I shall elaborate

shortly, they are in a much better competitive position.

The implication of this for the developing countries, such as Brazil and Korea, is that entering into the high stakes world of the global microelectronics industry will require that they formulate a unified front. That is, the state and national firms will have to pool their resources in order to achieve scale economies in R&D and production. For reasons cited below an oligopolistic industry structure would be highly conducive to this end.

Structural Changes in the Industry: Technology, R&D and Capital

Prior to the development of VLSI technology the transition to new technologies was favorable to the emergence and growth of small firms.¹⁹ The advent of VLSI in the early 1980s marked a technological watershed which was to have a profound impact upon the future course and development of the microelectronics industry. The technical demands of VLSI brought about major changes in device design, manufacturing techniques, and device technology which placed unprecedented pressure on microelectronics companies. The advent of VLSI substantially increased R&D and capital costs and thus dramatically increased the minimum efficient scale of operations in order to recuperate these costs.²⁰ The move to extra large scale integration in the near future will no doubt exacerbate these developments.

The increased complexity of ICs, arising out of increased chip density, which tends to reduce yields, has necessitated the automation of virtually every aspect of the manufacturing process. Today computers have become

indispensable in the design and testing stages of production. As a result the capital required to set up a production facility has escalated substantially over the years. For instance, in 1972 \$2 million was deemed sufficient for setting up a semiconductor production facility. In 1983 this figure had reached up to \$100 million for 64k DRAM production and 160 million for 256K DRAM production.²¹ The cost of device design has also skyrocketed- the cost of designing a 32 bit microprocessor was estimated at \$50 million in 1988.²² The outcome of these developments has been the creation of formidable barriers to entry in an industry where entrance was relatively easy at one time.

The nature of the new technology has also fostered the development of a new relationship between the upstream, midstream and downstream sectors of the microelectronics industry. The density and complexity of VLSI devices for instance has become so great that they can form entire subsystems or even systems on their own. A computer's entire processor for instance is now contained on a single chip no greater in size than a square inch. This has major implications for the downstream producers that incorporate these devices into their systems. With the blurring of the boundaries between the semiconductor sector and the computer sector, as a result of the new technology, merchant computer manufacturers are increasingly being relegated to the position of assemblers and sub-assemblers of components. The basis of product differentiation is increasingly being concentrated in the semiconductor sector. For computers, the emergence and rapid growth of ASICs has meant that differentiation is basically achieved through changes in circuit design and configuration of printed circuit boards. As a result, the pricing strategy of downstream firms, such as computer firms, has come to crucially depend on the prices of core components, particularly digital ICs.

The increasing systems orientation of the new technology is indicative of one of the key and perhaps most crucial phenomena in microelectronics technology today-the trend towards convergence. The implication of convergence is essentially twofold. First, the escalation of component integration within the product means a shift in value added away from final product manufacture to the components themselves and thus to component producers. Second, since the product is now part of an integral system, product suppliers will likely be led to integrate backwards into component supply and forward into becoming suppliers of virtual systems compatible with other systems. Thus, much closer relationships are being forged between upstream, midstream and downstream firms²³ resulting in a shift in competitive advantage to vertically integrated firms and consequently to major new technological and size barriers to entry.²⁴ The highly cyclical nature of profits and capacity utilization in the semiconductor sector (Figure 2.1 and 2.2) has also been responsible for shifting competitive advantage to vertically integrated firms.²⁵ Through vertical integration a firm can better plan and respond to market fluctuations. In regard to supply a firm can lower the risks of interruption and of paying prices in excess of market prices in emergency situations. With regard to demand a firm can assure itself of an outlet for its products in periods of low demand. The possession of a captive market provides vertically integrated firms with a market that can serve as a safety buffer against excessive demand fluctuations which are typical for the semiconductor industry.²⁶

Moreover, the escalating costs of R&D have made it virtually impossible for national governments let alone very large individual firms to go it alone. The competitive push towards greater chip density and higher processing speeds will require a quantum leap to newer technologies, such as optoelectronics²⁷ and

the use of gallium arsenide²⁸ in the manufacture of semiconductors, and stretch the resources of nations and corporations alike to the limits. At the same time product life cycles are becoming inordinately short, often having a duration of only three to four years and requiring that "new products be introduced every 12 to 18 months in order to maintain continuity." This has made it an imperative to quickly recover large investments which thus become a highly risky proposition. As a result of shortening product life cycles increasingly faster turnaround time has become a central driving force in the industry and thus it is becoming clear that achieving market dominance requires not only lowest cost product but also getting to the market first. Consequently, not only has the rapid pace of technological progress resulted in making learning curves steeper but it has also made it necessary for firms to travel the curve faster than ever before.

Aside from barriers to entry resulting from the necessity for scale economies in production and R&D there are also barriers to entry resulting from scale economies in marketing to consider. Due to the globalization of competition²⁹ it has become imperative for new entrants to establish a global market presence as quickly as possible. As a result, the minimum investment outlays required for marketing and product promotion have risen dramatically.³⁰ Conversely, in order to make marketing cost effective it is necessary for firms to establish themselves and sell globally so as to achieve economies of scale in marketing.³¹

The foregoing clearly exemplifies a Schumpeterian evolution of the microelectronics industry.³² According to Schumpeter, technological change required the existence of large firms and, moreover, the intensity of innovation and its rate of diffusion are positively correlated with market power. Schumpeter clearly felt that small firms were not an efficient medium for

carrying out the process of invention and innovation, for they are incapable of optimal expenditures for research and development. Therefore Schumpeter argued in favor of large firms, which he believed were more capable of maximizing technological innovation. Underlying this argument was Schumpeter's belief that technological change is itself an element of competition. As such, competition is not destroyed by the introduction of larger firms, rather, it is enhanced by efforts toward technological change.

Following in Schumpeter's footsteps, Galbraith argued that large firms were an almost perfect instrument for inducing technological change and are the most efficient originators and transmitters of technological change.³³ His conclusions emanated from the following reasoning. According to Galbraith R&D expenditures may be too costly for small firms to engage in because it is a time-consuming process. Small firms perhaps cannot wait for deferred rewards because they do not have sufficient financing. Additionally, there may be economies of scale in R&D so that large, necessary R&D efforts cannot be financed or justified in small firms. Furthermore, since R&D expenditures are risky, only large diversified firms may be able to spread this risk over a sufficiently large number of projects. Finally, perhaps only large firms can fully exploit the results of R&D efforts due to their diversified nature.

Trade, Technological Diffusion and the Developing Countries

The significance of trade in microelectronics lies not so much in its amount as it does in its reflection of technological change and the policies of governments and private enterprises due to the strategic characteristics of the

industry. Trade in this industry takes place in an environment determined in part by conflicting and heterogeneous national policies which are increasingly having a detrimental effect on trade and thus exerting increasing tension between the growing international interdependence within the microelectronics industry, in terms of markets and technology, and the quest by national governments for national competitive advantage. The result of this tension, to quote Ernst and O'Connor, is an "increasingly high tech neo-mercantilism which treats science and technology primarily as weapons in international competition."³⁴

Perhaps the most obvious manifestation of this high tech neo-mercantilism has been the proliferation of barriers to trade in high tech industries. While the Tokyo round of GATT negotiations resulted in the reduction of tariff rates across a broad range of sectors it largely failed to meet with any success in regard to non-tariff barriers. Non-tariff barriers include such mechanisms as administrative and technical standards, intellectual property right protection, government procurement policies in addition to the traditional quotas and ceilings on imports. They are generally much more effective weapons in reducing the flow of trade than are tariffs as they tend to replace the market mechanism altogether. The application of such protectionist measures to specific industries may be generally subsumed under the heading of *targeting*. Due to its strategic importance to a nation's overall productive capacity the microelectronics industry has been increasingly singled out, by developed and developing countries alike, for targeting. Even if such targeting does not explicitly spell out protectionist measures, the very fact that a sectoral policy exists and involves the commitment of national resources to the development of the microelectronics sector will suffice to induce protectionist measures to

safeguard the investment made.

Yet another dimension of high-tech neo-mercantilism can be witnessed in the emergence of bilateral and multilateral sectoral agreements for research into the development of new technologies and products. The most notable of such agreements is exemplified by the American semiconductor producers consortium, SEMATECH, which, as mentioned earlier, is intended to reverse the erosion of the U.S. position in semiconductor manufacturing.³⁵ As such programs discriminate against, or highly restrict, the participation of foreign corporations and are state supported through such means as subsidies and national or regional procurement policies they threaten the flow of trade and international technology diffusion.

The effect of such protectionist policies for the NICs has been to slow the rate of technological diffusion and increasingly restrict access to the markets of the developed countries. The slower rate of technological diffusion is particularly significant in microelectronics where the speed with which technology is acquired and brought to market has become a crucial factor in maintaining competitive advantage, due to the rapid stride of technological change.³⁶

To overcome the obstacles restricting access to the markets and technology of the developed countries, particularly for those NICs whose economy is geared towards export oriented development, it has become increasingly necessary for the NICs to foster the development of multinational corporations that can transcend national boundaries and barriers to trade and technology acquisition.

Conclusion

This chapter has attempted to summarize the key technological and economic factors that have characterized the microelectronics industry since the advent of VLSI technology and the subsequent move towards convergence. As stated in the introduction to this chapter the purpose of this undertaking has been to set the stage for Chapter Three's examination of the nature and role of state and corporate policies in the transformation of the global microelectronics industry. Moreover, it has attempted to lay the basis for Chapter Five's assessment of the different patterns of state intervention in the development of the microelectronics industry in Korea and Brazil in reference to the nature and pace of technological change characterizing the industry. As a result of the pace and nature of technological change formidable size and technological barriers in addition to neo-mercantilist trade patterns have emerged that have redefined the nature of competition in the industry along Schumpeterian lines. It remains to the next chapter to define what is meant by competitiveness and elaborate upon corporate strategies and the role of the state in bringing it about in reference to the microelectronics industry.

NOTES (Chapter Two)

10. Richard Langlois et al., Microelectronics: An Industry in Transition (Boston: Unwin Hyman, 1988), 26.

11. Langlois, 27.

12. John Bessant and Sam Cole, Stacking the Chips: Information Technology and the Distribution of Income (London: Francis Binter), 45.

13. This shall be discussed in chapter 5. The Brazilian informatics industry is similar to the U.S.'s, comprised of small "dedicated" firms.

14. Thomas R. Howell et al., The Microelectronics Race: The Impact of Government Policy on International Competition (Boulder: Westview Press, 1988), 16

15. This shall be discussed in greater detail later on under the topic "Structural Changes in the Industry: Technology, R&D and Capital."

16. George Anderla and Anthony Dunning, Computer Strategies 1990-9 (New York: John Wiley and Sons, 1987), IX.

17. Economies of scope are scale economies associated with the production of more than one product in a specific plant. According to Baumol:

In addition to economies deriving from the size or scale of a firm's operations there is also the possibility that cost savings may result from simultaneous production of several different outputs in a single enterprise, as contrasted with their production in isolation, each by its own specialized firm. That is, there may exist economies resulting from the scope of the firm's operations.

The quotation is from William J. Baumol, John C. Panzar and Robert D. Willig, Contestable Markets and the Theory of Industry Structure (New York: Harcourt Brace Jovanovich, Inc. 1982), 71.

18. Howell, 12.

19. This is due to primarily two factors. One, as noted earlier, the advent of new process and design technologies, which had the effect of lowering technological barriers to entry, were favorable to the emergence of small firms. And two, as Evans has pointed out, during periods of transition "technological change is accompanied by disjunction in established corporate control over technology," which can provide an opening for new firms. Peter Evans, "State,

Capital, and the Transformation of Dependence: The Brazilian Case," World Development, 1985, 803.

20. While learning economies have always played an important part in the microelectronics industry economies of scale were not previously considered to play a significant role.

21. Langlois, 46.

22. Howell, 28.

23. An example may help to illustrate our discussion. As VLSI devices have become increasingly system oriented there has been a dramatic growth in the market for application specific ICs, as discussed earlier. Consequently, semiconductor producers designing what may be termed 'a system on a chip' for an end (such as a computer or consumer electronics firm) user must become privy to many of its technological secrets in order to design a satisfactory product. Similarly, the semiconductor firm must divulge secrets to its equipment and materials suppliers to ensure that the suppliers goods meet its specifications.

24. As a result of the move towards convergence the line of demarcation between the computer and semiconductor industries is becoming increasingly blurred. As a consequence of the fusion of technologies, as exemplified by the development of "systems on a chip," semiconductor producers have become the key holders to computer technology and have begun to integrate forward into the computer sector. Conversely, the nature of technological change is forcing traditional computer producers to integrate backward into the semiconductor sector.

25. For a definitive account of the reasons and determinants of vertical integration and why firms wish to vertically integrate see: Kenneth W. Clarkson and LeRoy Miller, Industrial Organization: Theory, Evidence and Public Policy (New York: McGraw Hill, 1982), ch. 14.

26. As Ernst and O'Connor point out, the existence of a captive market also conveys to vertically firms the advantage of having "fast access to feedback information on the performance of particular circuits in particular systems..." Dieter Ernst and David O'Connor, "Technology and Global Competition: The Challenge for Newly Industrializing Economies," Development Center of the Organization for Economic Cooperation and Development (OECD), 1990, 85. This in turn provides vertically integrated firms with an edge in terms of getting to the market fast as they are able to obtain information regarding product performance and use faster than merchant firms.

27. The desire for enhanced speed has led to the development of an entirely new form of devices- optoelectronics and optical semiconductors- which employ light instead of electricity as a conductor and can therefore deliver speeds hundreds of times faster than conventional electronic based devices. It should be noted, however, that the technology is still in its infancy and it will be a number of years before its application becomes widespread.

28. The limitations of silicon for handling greater chip density has compelled the development of new semiconducting materials, notably gallium arsenide, which are capable of handling greater densities.

29. The issue of globalization shall be discussed in greater detail in the following chapter.

30. Dieter Ernst and David O'Connor, "Technology and Global Competition: The Challenge for Newly Industrializing Economies," Development Center of the Organization for Economic Cooperation and Development (OECD), 1990, 32. They illustrate this statement by quoting a U.S. electronics industry executive who states "there is so little labour content left in our products that even if the robots were provided free it would hardly affect our costs. For us direct labour costs are peanuts compared to what we have to pay for marketing and distribution."

31. One of the principal determinants between advertising and market concentration, which is indicative of oligopolistic barriers to entry, is scale economies. In fact it is estimated that advertising is the single most important factor in explaining price and cost differentials of established firms relative to new entrants. Economies of scale in advertising arise from several different factors, including: a minimum saturation level, cumulative effects and quantity discounts. Advertising campaigns often must reach a certain minimum expense level before they are cost effective, as many of them carry high common or fixed costs. Kenneth W. Clarkson and Rodger LeRoy Miller, Industrial Organization: Theory, Evidence and Public Policy (New York: McGraw-Hill, 1982), 223.

32. Joseph A. Schumpeter, Capitalism, Socialism and Democracy (New York: Harper and Row, 1942).

33. John Kenneth Galbraith, American Capitalism: The Concept of Countervailing Power (Boston: Houghton-Mifflin, 1956), 86-90.

34. Ernst and O'Connor, 26.

35. Howell, 12.

36. More light shall be shed on this later on.

CHAPTER THREE

Competitiveness and The Role of Agency

Introduction

In the foregoing chapters I sought to establish the empirical foundation of this study. Here, by building on what has gone before, I propose to settle the conceptual foundation that shall serve as a guide in my subsequent analysis of the development of the microelectronics industry in Korea and Brazil.

On several occasions in the previous chapter I alluded to technological developments in the microelectronics industry that have been crucial to the maintenance and development of national and corporate competitiveness in this industry. In this chapter I shall set out to explore and define the concept of competitiveness with reference to high technology industries, particularly microelectronics. I shall argue that competitiveness is in large part the result of the role of agency and thus repudiate the notion of competitiveness as an immutable fact of comparative advantage or the new international division of labour. Subsequently, having established the definition of competition and the importance of agency in bringing it about, I shall examine the role of agency. Specifically, I shall briefly canvass the relevant range of corporate and government strategies aimed at fostering the development and acquisition of technological knowledge in reference to the microelectronics industry.

The Concept of Competitiveness

Competition and the concept of competitiveness are profoundly dynamic in character. The traditional static explanation of competitiveness and international trade in terms of comparative advantage is to a great extent a relic, made obsolete by national industrial policies.

According to classical economists, comparative advantage was based on the difference in the productivity of labour (the only factor of production they explicitly considered) among nations, but they provided no such explanation for such difference in productivity, except for possible differences in climate. The Heckscher-Ohlin theory³⁷ of factor endowments went beyond classical economic theory by examining the basis of comparative advantage. It postulated that a nation will export the commodity whose production requires the intensive use of the nation's relatively abundant and cheap factor (natural endowment) and import the commodity whose production requires the intensive use of the nation's relatively scarce and expensive factor. Despite the theory's merit in going beyond classical economic thought it nevertheless fails to account for such factors as economies of scale, technological advance, product cycles and, above all, technological knowledge, the greatest attribute of which is human capital, perhaps the foremost natural endowment of any nation. Consequently, the theory, and this is its greatest pitfall, takes comparative advantage as given. It forsakes the very real possibility that comparative advantage can be created through such means as industrial policy, not to mention other means such as monetary and fiscal policy. If developing countries were to accept their given comparative advantage, that is, their given natural resource endowments, as the basis of their competitive ability they would in essence be relegating themselves

to a state of backwardness and dependence and suffer the consequences thereof.

Therefore, we must go beyond reductionist interpretations of competition in terms of comparative advantage. Given the increasing dominance of vertically integrated multinational corporations in the global economy, and hence the emergence of global oligopolistic structures, and the global nature of much of the new technology, the concept of competition can no longer be limited by national boundaries within the construct of comparative advantage. Today, more than ever, we are living in a world "in which comparative advantage, international competitiveness, and the international division of labour results in large measure from corporate strategies and national policies rather than from natural endowments".³⁸ This understanding goes against the very grain of the concept of the new international division of labour, as put forth by Froebel et al. According to Froebel et al. the "new division of labour is an institutional innovation of capital and not at all the result of changed development strategies or fortuitous decisions of so-called multinational companies."³⁹ Explicated in these terms the concept suffers from the same syndrome as comparative advantage in its total disregard of the role of agency in the formulation of competitive ability. At the core of the explanation concerning national advantage in an industry must be the role of the home nation, its firms and more importantly the state in stimulating competitive improvement and innovation.

Competition (defined here in a global context given the prevailing understanding that firms do not compete in nations but in industries) as Ernst and O'Connor argue "is about internalizing on a worldwide scale key assets such as knowledge, production experience and market access, that can lead to the development and to the effective commercialization of a wide variety of products and services."⁴⁰

Demand

Demand conditions play a prominent role in this process of internalization. The influence of demand conditions on competitive ability can be assessed in terms of both the static and dynamic efficiencies that it confers upon firms. Static efficiencies are primarily associated with economies of scale and learning resulting from the presence of large market demand. Where the home market is small it is possible to achieve static efficiency through export activity. While static efficiencies play a significant role in a firm's competitive ability, dynamic efficiencies often play a far more important role especially in high technology industries.

Dynamic efficiencies are achieved when demand conditions are of a sufficiently sophisticated nature that they pressure firms in an industry to learn and innovate faster and thus achieve a greater sophisticated advantage in relation to rivals.⁴¹ This comes about through a process which Rosenberg refers to as learning by using. According to Rosenberg learning by using can result in the development of two different kinds of knowledge; embodied or disembodied.⁴² The former refers to the development of an "understanding of the relationship between specific design characteristics and performance that permit subsequent modifications and improvements in design." In contrast the latter refers to the development of knowledge about "new practices that increase the productivity of the product," such as increasing its reliability. Since knowledge derived from learning by using is associated with product use its development tends to require a high degree of interaction between producers and the market. The more sophisticated and demanding the market, the more sophisticated is the knowledge gained. Learning by using plays an important role in high technology industries. In microelectronics for instance, as chip

density has increased over the years so has the need for greater product reliability and more complex circuit designs.

The kind of knowledge associated with learning by using differs from that associated with innovation corresponding to R&D. Here we can distinguish between two forms of learning, one corresponding to research, the other to development. The former involves doing basic scientific research in order to acquire knowledge concerning the laws of nature. While this form of research is carried out primarily for the sake of knowledge it can be of vital use in terms of commercial application particularly in high technology industries. For instance, in microelectronics an understanding of the laws of physics is essential to increasing chip density.

In regard to the development aspect of R&D "...learning is oriented toward the commercial dimensions of the innovation process: discovering the nature and combination of product characteristics desired in the market...and incorporating these in a final product in ways that take into account scientific and engineering knowledge."⁴³ Thus it becomes apparent that there exists a feed back loop between learning by using and the development aspect of R&D, since experience with product use enables producers to decipher the product characteristics desired by the market. And once again the more sophisticated the market the greater the dynamic efficiencies associated with demand.

Such efficiencies play a critical role in an industry such as microelectronics where innovative ability is crucial to competitive advantage. However, developing country firms engaged in high technology industries are limited in their ability to achieve dynamic efficiencies due to the largely unsophisticated nature of their home markets as indicated by the small size of their per capita gross domestic product (GDP) in comparison to that of the

OECD countries. To overcome this obstacle microelectronic firms in developing countries need to access the more sophisticated markets of the industrialized countries. Lacking the innovative capacity to meet the sophisticated demand structure of these markets, penetration of these markets by developing country firms usually requires the possession of competitive advantage in static efficiencies based on economies of scale and low cost production that would make them attractive as original equipment manufacturers (OEM) for brand name producers in the OECD countries. If access is secured, developing country firms may over time develop dynamic efficiencies by meeting the demands of a more sophisticated market.

However, in the long run reliance by developing country firms on the markets of OECD countries for the sustainment of static and dynamic demand efficiencies is no panacea and should be seen only as a short term solution. This is particularly so given that securing access to OECD markets is becoming an increasingly precarious proposition in light of escalating trade barriers, especially in the area of strategic industries such as microelectronics.

Ultimately, the development of a sophisticated and large home demand base is vital to the long term development of static and dynamic efficiencies that figure prominently in the competitive advantage of firms and nations alike. In this respect income plays a pivotal role in increasing both the sophistication and the size of the home market. Increases in real wages lead not only to an expansion of market size but can also lead to a potential increase in home buyers sophistication. As such, for developing country high technology firms moving up the ladder of technological capability requires a shift away in strategy from competitive advantage based on low cost production through the suppression of real wages to competitive advantage based on innovation which is stimulated by

higher real wages.⁴⁴

In essence the international competitiveness of a national economy depends upon the competitiveness of the firms which operate within its borders. Their competitiveness in turn depends upon their ability and the manner in which they go about internalizing key assets such as technological knowledge and their subsequent commercialization of this knowledge.

Corporate Strategies

Corporate strategies in carrying out the process of internalization vary from industry to industry and even within industries. Nevertheless, each industry is to some extent characterized by certain prevalent strategies which serve to delineate it from other industries. In high technology industries, and in particular the microelectronics industry, the nature of the technology has increasingly focused corporate strategies around vertical integration, strategic alliances, and globalization. As the essential reasons for the move towards vertical integration were discussed in Chapter Two the discussion here shall be limited to strategic alliances and globalization.

Strategic Alliances

Firms enter into strategic alliances to gain a number of benefits. One is economies of scale or learning, achieved through joining forces in component production, or assembly. A second benefit, of particular significance for the microelectronics industry, is to access local markets and needed technologies as exemplified in the previous chapter.

Strategic alliances tend to proliferate in industries undergoing structural change or escalating competition, as in the microelectronics industry due to the rapid pace of technological progress, and are therefore essentially a response to uncertainty. Therefore, alliances should be viewed essentially as transitional devices in periods of uncertainty. They should by no means be viewed as a means to sustain competitive advantage in the long-term. This ultimately requires the development of internal capabilities by each firm in areas of significance to competitive advantage.

Globalization

Firms do not compete in nations, they compete in industries and in global industries such as microelectronics sustaining the competitive advantages derived from vertical integration, strategic alliances and demand conditions requires an overall global approach to strategy. This is particularly so for developing country firms for which the technological frontier, in terms of both markets and factors, lies not at home but abroad. However, in order to reach the technological frontier requires the prior development of some home based advantages relating to demand efficiencies. This can be achieved, as alluded to earlier, mostly on the basis of static efficiencies.

The purpose of a global approach is essentially to supplement home based advantages and help reduce home based disadvantages. The execution of such a strategy involves a number of ambient factors. First, it naturally requires selling globally. In doing so the firm builds itself an internationally recognizable brand name and establishes an international marketing and distribution network under its own control. Thus, the firm acquires a larger share of value added and more importantly stimulates innovation in regard to organization and marketing

capabilities. Moreover, due to the globalization of competition and the importance of brand name recognition and quality in the downstream sectors of the microelectronics industry, as discussed elsewhere, it is imperative that firms, as part of their competitive strategies, establish a global market presence, especially in the major markets of the OECD countries.

An additional and perhaps more important advantage of export activity is that it can hasten the process of developing technological capabilities, particularly those that pertain to production and investment capability. As suggested in Chapter Two, export activity can, by inducing the emergence of scale production, quicken the rate at which firms travel up the learning curve. This proposition is supported by Westphall who has noted that "it is very likely that infant-industry exports will yield sizeable net benefits because export activity appears to accelerate the acquisition of technological mastery and hence to hasten productivity improvement and efficiency gains."⁴⁵

In situations where an industry's domestic market is of limited economic size the emphasis that global strategies place on exports can also avoid the growth inhibiting effects associated with import substitution strategies. In cases where the domestic market is small one firm's gain of the market share is often achieved at the expense of another firm's share, resulting in a zero sum situation. In global strategies, however, corporate energies are directed toward the world market where the chances of one firm's gain reducing another's are considerably reduced if not eliminated.⁴⁶

Second, it requires the location of activities in other nations. There are primarily two reasons for doing so. One, to capture local advantages; the most prominent of which are technological factor conditions including human skills and the collection of market intelligence that can provide firms with invaluable

information regarding market trends. Such information is of crucial importance in the microelectronics industry where, as revealed in the previous chapter, as a result of shortening product life cycles, faster turn around times and getting to the market first have become essential ingredients in maintaining and enhancing competitive positions. And two, to facilitate market penetration. Locating activities in other nations, particularly in the OECD countries, plays an important role in sustaining the long term competitive advantage of developing country high technology firms given their technological lag in relation to OECD firms and the rising trade barriers in the OECD countries, particularly in the area of high technology products and services.

The third element in the execution of a global strategy is an extension of the second and involves the coordination and integration of activities on a global basis. Coordination may lead to economies of scale and learning by allocating different tasks to subsidiaries, thus allowing specialization. Moreover it allows for the development of an internationally recognized brand name reputation.

The object of a global strategy is essentially to supplement home based advantages and not to substitute for innovation and improvement at home. But choosing a domestic focus in a global industry is precarious to say the least, no matter what the firm's home nation. In global industries firms are compelled to adopt a global approach in order to achieve or preserve competitive advantage particularly in the most dynamic and important industry segments. Global industries such as microelectronics are the battleground in which firms from different nations compete in ways that significantly affect national economic prosperity. As such the ability to achieve and/or maintain competitive advantage in these industries carries high stakes for firms and nations in terms of international trade and investment.

Strategies: The Role of the State

Corporations and their strategies are only one aspect of the intricate process of developing technological capabilities. To gain any real insight into the differences that characterize the development of a single industry in two nations it is essential to go beyond the role of corporate strategies and look at the differences "... between alternate production, institutional schemes and social organizations in which business enterprises figure prominently but are nonetheless only one component of a network that links them with the educational system, the technological infrastructure, management/labour relations, the relationship between the public and private sectors, and the financial system."⁴⁷ Therefore, an understanding of the role of the state is crucial to an understanding of the development of technological capabilities and competitive advantage.

Although technology is first and foremost a corporate concern, responsibility for creating the conditions under which firms can build their competitive strengths lies primarily with government. It is, therefore, no surprise to find that heavy state involvement has increasingly become a pervasive force in the development of technological capabilities which underlie the competitive positions of nations. The manifestation of such policies has been particularly acute in the microelectronics industry due to the generic nature of the technology which makes it a catalyst for increasing the productivity of a broad spectrum of industries ranging from textiles to aircraft. Research and development projects such as the ESPRIT in the EEC and the VHSIC in the U.S. are but a few examples.⁴⁸

In late industrializing countries, such as Korea and Brazil, their lateness

to the process of industrialization has required even greater state involvement than in the industrialized countries, particularly in high technology industries. Lacking a sufficiently developed technological core, particularly in such areas as R&D and human capital formation, which possesses the competence to regenerate based on its own resources, has required a sustained and coordinated effort on the part of the state, in conjunction with industry and research institutions, for the development of strategic industries.

However, there are no golden rules, no specific prescriptions, no blueprints that dictate what policies or set of policies a state should adopt in its bid to develop the technological capabilities of the nation. This ultimately depends on the unique national circumstances facing a nation at a particular point in time. How the state (defined here as the entity composed of central decision makers and permanent bureaucracy) responds to particular circumstances in turn partly reflects the cumulation of a set of historical circumstances that have contributed to shaping the state's ideological outlook in regard to its developmentist role. The words 'partly' and 'contributed' are used to deflect any deterministic understanding of the state's role. While humans are historical beings, they are also cultivators of history through the decisions that they make based on the choices available to them at any particular point in time; and the *prima facie* means by which every human society makes these choices is through the institution of the state. Thus the state is not merely a passive conduit of history, it is a major actor in deciding how history unfolds.⁴⁹

Any understanding of the state's role as an actor must confer upon the state a relative sphere of autonomy within which to act. A sphere within which it can create an environment conducive to the development of industries and competitive forces. However, it does so not in a vacuum but within the confines

and in response to national and international forces as represented by the likes of domestic firms, social structure and multinational corporations.⁵⁰

The general thrust of state policies in late industrializing countries has not been to conform to market forces but rather to rectify, manipulate and even to override them so as to create an environment conducive to industrial growth and development. The conditions under which the state does so and the precise policies that it chooses and how it implements them depend upon the nation and industry in question. Therefore, I shall reserve detailed discussion of the state's role until Part Two, where I shall undertake a case study of the microelectronics industry in Korea and Brazil. However, in terms of general spheres of policy, through which governments can effect the development of a technological core, there are four areas which can be considered now. These are procurement, industrial strategy, technology transfer, research and development and human capital.

Procurement⁵¹

The most direct effect of government on demand conditions is via its role as a buyer of many goods and services. Government procurement has often played a pivotal role in the early development of strategic industries. This was the case in the early years of the U.S. microelectronics industry where government procurement accounted for virtually 90 percent of the demand for semiconductors.

Government procurement can have either positive or negative consequences depending on how it is implemented. It can have negative consequences if it becomes a guaranteed market. In such a situation the government market may become the focus of attention of domestic firms and

thus retard the development of a diversified product base serving the needs of the larger market. This in turn will result in stunting the evolution of domestic firms on a competitively viable basis. Moreover, government procurement may result in reducing competition if it shuts off foreign firms or is restricted to a handful of domestic firms for a protracted period of time. In such a scenario domestic firms will become complacent about innovation and upgrading and their products will lag behind in quality and features demanded internationally. Thus domestic firms will lack the ability to compete internationally and require even greater favoritism at home in order to survive.

Government procurement can have positive consequences in terms of developing and upgrading national competitive advantage under the following circumstances:

Early Demand: Government procurement can play an incisive role in the development of new industries and products by providing an early basis of demand. Such demand is critical in nurturing the early growth and development of industries, as depicted in the case of the U.S. microelectronics industry.

Setting Standards: Rather than simply accept the products of domestic suppliers, government purchases should set stringent product specifications and quality standards and seek product diversity and sophistication. This should be done, to the extent possible, in accordance with globally competitive standards rather than reflecting only the peculiar needs of the nation for reasons cited earlier. Doing so is an economic imperative for maintaining and achieving competitiveness given the proliferation of international product quality standards.

The above analysis of government procurement is equally applicable to other government policies aimed at infant industry protection, such as that of

market reserve. This policy, involving the reservation of a specified segment of the market solely for domestic firms, has been particularly prevalent in developing countries in the development of strategic industries such as microelectronics, as shall be exemplified in my discussion of the microelectronics industry in Brazil and Korea in the subsequent section. Where scale economies are present market reserve and import controls should be used as a tool by the government to protect the home market from foreign competition for a *limited time*, thus allowing domestic firms to exploit scale economies through increased market share in the domestic market. This then translates into lower cost for exports to foreign markets. Therefore, domestic protection can be used as a form of export promotion when scale economies are present. Exports, in turn, will result in further costs reductions and speed up the learning process thus making firms more competitive in global markets. To take advantage of export opportunities, however, will require that protection be time bound and implemented within the context of a global strategy.

To justify protection an infant industry must eventually be capable of competing against imports in the home market, or a stronger condition, as an export sector. This suggests that protection should decline towards zero as productivity increases and costs fall. This decline itself will stimulate, or rather accelerate, increases in productivity given the looming competition. In general, protracted protectionist policies, more often than not, result in un-competitive industries incapable of penetrating and partaking in the global market as Chapter Five's exposition of the Brazilian microelectronics industry shall exemplify.

Industrial Strategy

As discussed earlier preserving and improving competitive advantage in global industries requires that firms take a global approach to strategy. A nation's choice of industrial regime is the primary enabling factor in the ability of firms to undertake such a strategy. These are briefly summarized below.

On the broadest level, there can be distinguished two types of industrial strategies: outward oriented and inward oriented. An outward oriented strategy, as defined here, goes beyond merely export-substitution, it involves a global outlook on the part of a nation's firms and government. Within such a strategy exports and the location of subsidiaries overseas are not seen simply as a means to increase export earnings, although this is the primary concern, but also as a means to access technology and human capital in addition to taking advantage of the dynamic demand efficiencies that may be absent or lacking, as they often are in developing country markets, in the domestic market. Firms are encouraged to operate on the world market and thus reap the full rewards of local competitive advantage (labour skills, quality of the industrial fabric, access to scientific and technological resources, and so on), and rely on the interaction and accumulation of skills and knowledge worldwide. Moreover, the state itself may invest abroad to establish R&D institutes affiliated with home institutions as a means to source foreign technology and human capital. As shall be seen in Chapter Five, these measures have been effectively employed by the Korean state in the development of the microelectronics industry.

Inward oriented strategies on the other hand are geared to the domestic market and based primarily on import substitution. The emphasis on import substitution by no means excludes exports or the importation of indispensable technology. However, they lack a global outlook and place much greater

emphasis on self-sufficiency in the development of technological capabilities than do outward oriented strategies. Consequently, such strategies are not as adept as outward oriented strategies in sourcing technological knowledge on a world scale. Moreover, the emphasis on the domestic market and self-sufficiency tends to undermine the development of globally competitive industries that keep abreast of technological change occurring worldwide and thus the long term competitive sustainment of high technology industries.

An added drawback of import substitution strategies, discussed earlier, is their growth inhibiting effects in cases where the domestic market is too small to permit vigorous competition amongst local firms. As shall be seen in the Chapter Five, this situation is characteristic of the Brazilian informatics industry.

Import substitution regimes also have a tendency to limit backward industrialization. Once downstream industries have been started it is natural to seek further import substitution by producing at home the intermediate goods used by downstream industries. However, because the domestic market for intermediate goods, such as semiconductors, is frequently smaller than for final consumer goods, such as computers, and for some producer goods industries, where economies of scale are large, as in the semiconductor sector, there is a natural barrier to investment in these industries. This could be overcome by protection, such as market reserve, but this would drive up the costs of inputs to already established downstream manufacturers whose profits depend upon protection for their products and low duties for their inputs. Consequently the price of downstream products will rise above international prices for similar products and domestic products will be uncompetitive. Again, this affliction, as shall be seen in Chapter Five, is characteristic of Brazil's informatics industry.

Technology Transfer

In its simplest form technology transfer means the transfer of embodied technologies (machinery and equipment) and related inputs necessary for the production of specific goods and services. However, as Mytelka points out "importing embodied technology and learning to operate it does not in itself constitute a capacity to reproduce that technology or to use it for purposes other than that for which it was originally designed."⁵² What is required therefore is a development oriented understanding of the concept. Such an understanding would imply that the recipient of technology will eventually be able to absorb the technological capacity that underlies the technological asset. Viewed as such, the full absorption, assimilation and diffusion of technologies and the development of indigenous capacities for adaptation and innovation will constitute the real test of effectiveness of the transfer process. Much of this depends upon the technology recipient, one of the primary objectives of whom should be to ascertain whether such aspects as mentioned above are included in the transfer and if not to attempt to remove the obstacles that hinder such inclusion.

The choice of industrial strategy is the preeminent factor in determining a nation's stance in regard to technology transfer. Outward oriented strategies are inclined to cultivate a progressive stance in regard to the importation of foreign technology. Indeed, a prime function of exports is to provide the foreign exchange needed to purchase foreign technology. In turn, the incorporation of foreign technology results in the upgrading of productive capacity and thus bolsters the competitiveness of manufactured exports in the world market.

On the other hand, to the extent that import substitution regimes emphasize self-sufficiency in industrialization they are inclined to foster a

regressive stance in regard to technology transfer. Radical elements of the dependency school, such as Gunder Frank,⁵³ who are supportive of self-sufficient import substitution regimes, view the importation of foreign technology as inimical to the development of indigenous technological capabilities. Unfortunately such an outlook is highly misleading as it is mired in an ideological dogma which throws up a smoke screen to the reality of global technological interdependence. Of course there are varying degrees of dependence. The crucial point to note is that dependence in an interdependent relationship should be viewed in terms of degrees, or relativity and not in terms of kind or absolutes.

Providing that mechanisms for the successful absorption and diffusion of foreign technology are in place, technology imports will have the effect, more often than not, of complementing the development of indigenous technological capability rather than retarding it. Indeed, as Sanjaya Lall has aptly demonstrated in his case study of India, too great an emphasis on a policy of self sufficiency in regard to the development of technological capability can result in technological stagnation and obsolescence.⁵⁴ Moreover, as another author notes:

An increase in the rate of penetration of manufactured imports as well as an increase in the purchase of foreign technology cannot be systematically seen as a sign of weakening competitiveness in the domestic market. The modernization of productive equipment can justify these types of purchases, and such modernization in principle signals an improvement in competitiveness.⁵⁵

Therefore the quandary is not one of either/or, between buy all and make all, but of designating the optimal middle ground between the two. This is no easy task and depends to a large extent upon the industry and technology in question and the peculiar circumstances facing a nation at particular points in

time such as its balance of payments situation and more importantly its internal technological capability and structures. However, on a general level it may be noted that for developing countries engaged in high technology industries such as microelectronics the optimal point tends to be skewed towards a more liberal stance in regard to technology imports given their relative lack of resources in light of the rapid and complex nature of technological change which characterizes the industry.

The success of technology transfer can be greatly influenced by the intervention of governments, from the selection to the assimilation of the technology. The main rationale for government intervention from the standpoint of developing countries lies in the imperfect nature of the technology market, particularly in industries such as microelectronics where oligopolistic structures dominate the market. To offset the advantages enjoyed by technology suppliers in such a market and thus buttress the position of domestic firms it becomes essential for the state to enter into the bargaining process as a regulator, director and monitor of the technology transfer process.⁵⁶ Indeed the state itself may be the agent of technological acquisition. The main rationale for doing so is to ensure the widespread diffusion of the technology to domestic firms. In Korea, as shall be seen in Chapter Five, this has been one of the primary functions of the Electronics and Telecommunications Research Institute.

Government strategies and policies for the transfer of technology have to address the issue of interfacing imports of technology with domestic technological capabilities. In other words, the choice of which technology to import must be governed by the degree of complementarity with the technologies under development by local firms. To this end the development of an indigenous R&D infrastructure and human resources is vital.

Research and Development

Based upon our previous discussion concerning the existence of a feed back loop between learning by using and the development aspect of R&D private firms are the most efficient agents for carrying out R&D activities. Compared to government agencies and enterprises, private firms are much more closely attuned to market forces and conditions and are therefore the best equipped in deciphering the type of R&D required in responding to these factors. Moreover, since firms, unlike governments, may go bankrupt they are much more inclined to be efficient and commercially prudent in their R&D activities.

However, government support and involvement in the process of R&D in the microelectronics industry has become essential due to the rapid pace of technological change, the high costs of technological R&D associated with the industry and the need for greater spending on the research component of R&D, which firms tend to relegate to a secondary position as it is more capital intensive and less commercial and profit oriented than the development component of R&D. For instance, as basic research falls in the domain of public knowledge and is associated with externalities which will benefit a broad segment of the economic and technological core of a nation, this task falls primarily to the state. Nonetheless, the state, through such means as tax incentives, can also encourage firms to fund basic research.

Governments may get indirectly involved in the development of new technologies and products through such means as subsidies to individual firms or to academic or industrial institutions engaged in R&D activity. Subsidies to firms can take a variety of forms ranging from tax incentives to outright financial grants. As in the case of government procurement, subsidies to firms can have

either negative or positive results. To have a positive effect government subsidies should be specific about the purposes for which they are being allocated. To this end they should be periodically reviewed to insure compliance with the terms of the subsidy and phased out according to some timetable allowing for targets to be met or withdrawn in cases of failure with little hope in sight. Otherwise firms are likely to become complacent subsidy addicts acting as a drain on scarce government resources with high opportunity costs.

To ensure the diffusion of technological knowledge from academia to industry and from industry to academia through a feed back loop the state can work to foster a close relationship between the two. As noted earlier on in our discussion of demand efficiencies, the existence of a feed back loop between the market and the development aspect of R&D is essential to the development of innovative capacities in firms. To this end it may get directly involved in the R&D process by establishing national research institutes, which in addition to their research function can serve as a conduit between industry, academia, and government centers for R&D. Moreover, such institutes may also be used in the training of personnel, particularly high level human capital such as scientists and engineers, crucial to the R&D process.

Human Capital

The entry of a country into capital and knowledge intensive industries such as microelectronics, requires an abundant supply of skilled labour that only the state can provide in adequate amounts.⁵⁷ The most essential element in carrying out R&D activity and ensuring the successful assimilation of foreign technology is the prior and continuous development of a human resource base at various levels of skill intensity. This requires not only a comprehensive policy

framework in regard to general education at the macro level but educational programs aimed at the development of specialized skills in various sectors at the micro level.

In line with the needs of R&D activity and technological absorption and development capacity, the aims of programs at the micro level would be to foster the capacity for rapid technological assimilation and innovation entailing the development of highly specialized skills in basic science, engineering, design, and technological management.⁵⁸ This would require the provision of guidelines regarding the development of skills in targeted areas and the coordination of the activities of vocational schools, universities, research centers and corporate training programs so as to eliminate any redundancy and ensure the development of the required skills in the targeted areas.

Conclusion

In this chapter I have suggested that competition is essentially a process of internalizing knowledge and its subsequent commercialization. Demand conditions figure prominently in this process as they are an essential element in setting the framework for the process of internalization.

Internalization is itself a function of agency; a function of corporate and state strategies and not a given. The establishment of this point sets the stage for and legitimizes the discussions in Chapters Four and Five, where the brunt of the analysis shall focus on the different state and corporate strategies employed in Brazil and Korea in the pursuit of the goal of industrialization with particular regard to the microelectronics industry. These strategies vary in accordance with

the industry in question. In the case of global industries such as microelectronics the focus of corporate strategies has been globalization, strategic alliances and vertical integration in accordance with the Schumpeterian evolution of the industry as described in the previous chapter. Considerations of the state's function in this regard were dealt with in reference to fostering macro factors, conducive to corporate strategies, delaying discussion of specific policy tools to the next section. Taking into account the rapid pace of technology transfer in the industry and the burgeoning R&D requirements, emphasis was placed on the need for a progressive and liberal stance in regard to technology transfer and protectionism.

My discussion in this chapter has been primarily developed in an abstract context with little specific reference to concrete situations. This shall be provided in the subsequent and final section of this work. As noted earlier, the purpose of the preceding chapters has been to establish the framework and measure for the core of this study. With this in mind I now turn to an assessment of the development of the microelectronics industry in Brazil and Korea.

NOTES (Chapter Three)

37. Dominik Salavatore, International Economics, 2nd ed (New York: Macmillan Publishing Company, 1987), 99-101.

38. Robert G. Gilpin, "Implications of the Changing Trade Regimes for US-Japanese Relations" in Inoguchi et al., eds. The Political Economy of Japan: The International Context, Vol 2. (Stanford University Press, 1988), 164.

39. Foker Frobel et al., "The World Market for Labour and the World Market for Industrial Sites," in Journal of Economic Issues, XXXII, 4 December 1978, 849.

40. Ernst and O'Connor, 25.

41. A number of examples support this hypothesis. For example, as Porter has noted in the case of Japan "consumers are highly sophisticated and knowledgeable in purchasing audio equipment (and so) they gather the latest extensive product information and want the latest, best models...Their desire for quality leads to rapid improvement by manufacturers. Michael E. Porter, The Competitive Advantage of Nations (New York: The Free Press, 1990), 89. Another example would be that of the Japanese automobile industry. Given Japan's heavy reliance on imported oil, and the country's small roads and land mass and high population density, Japanese consumers demanded, in accordance with their environment, small energy efficient cars. Japanese producers complied and today Japan is the world's leading producer of small fuel efficient automobiles. Indeed it was on the basis of this competitive edge that Japanese auto producers, initially, became world leaders in the global automobile industry.

42. Nathan Rosenberg, Inside the Black Box: Technology and Economics (Cambridge: Cambridge University Press, 1982), 123.

43. Rosenberg, 124.

44. Increases in real wages which keep pace with productivity are perhaps the single most important factor in stimulating the creation of a large and sophisticated demand base. Unfortunately the practice in most newly industrializing countries (NICs) has been for the state to suppress increases in real wages as a means to maintain competitive advantage based on low cost production. Such a strategy, particularly for the first tier NICs such as Brazil and Korea engaged in high technology industries, is both counterproductive and is proving increasingly difficult to maintain due to two interrelated factors. First, for reasons cited earlier it is counterproductive to the development of innovative capabilities. Second, it has become increasingly difficult for first tier NICs to

maintain such a strategy as witnessed by their gradual loss of competitive advantage in mature and labour intensive industries such as textiles to second and third tier NICs who enjoy much lower labour costs. As such, in first tier NICs the maintenance and improvement of their position in the world economy requires the creation of competitive advantage on a higher level, namely, on the basis of innovative capabilities, in the development of which higher real wages play a prominent role.

45. Larry E. Westphall and Foster "Technological Mastery by Means of Elective Infant Industry Protection," in M. Syrquin and S. Teitel, eds., Trade, Stability, Technology and Equity in Latin America (New York: Academic Press, 1982), 272.

46. Yongil Lim, Government Policy and Private Enterprise: The Korean Experience in Industrialization (California: Institute of East Asian Studies, University of California Center for Korean Studies, 1981), 20-21.

47. F. Fajinzylber, "Technical Change and Economic Development Issues for a Research Agenda," Quoted in Ernst and O'Connor, 26.

48. The European Strategic Program for Research and Development in Information technologies (ESPRIT) was established in 1983 by the European Commission. The purpose of ESPRIT is to provide the European information sector with the technology base needed to achieve parity with Japan and the United States within ten years. The Very High Speed Integrated Circuit Program (VHSIC) was established by the U.S. government as a defense related joint project. Its goal is to combine the density levels of commercial VLSI devices with characteristics of particular interest to the military, particularly speed of operation. It was envisioned that the program would have commercial spin-offs.

49. My interpretation of the state's role draws on the views of contemporary Marxists, particularly those of Miliband, Alavi and Pulantzas, who attribute to the state a relative sphere of autonomy within which to act. For a comprehensive account of the views of contemporary Marxists in regard to state see: Amseh Alavi and Teodor Shanin eds., Introduction to the Sociology of Developing Societies (London: Macmillan Press, 1982), and David Wells, Marxism and the Modern State (Sussex: Harvesters Press, 1981).

50. Thus, we concur with Amsden in her critique of Lipietz's conception of state autonomy in the process of industrialization. As Amsden argues "Lipietz focuses on the degree of state power to the exclusion of two other critical issues related to the state: the conditions under which the state acts 'developmentally'... and the precise policies which the developmental state follows in order to further industrial growth." Alice Amsden, "Third World Industrialization: 'Global Fordism' or a New Model?" in New Left Review, July/August 1990, 12.

51. In what follows I draw heavily upon the works of Michael E. Porter, The Competitive Advantage of Nations, op.cit, and Robert E. Baldwin, "The Case Against Infant Industry Protection," Journal of Political Economy 77 (1969) 299-305.

52. Lynn K. Mytelka, "Stimulating Effective Technology Transfer: The Case of Textiles in Africa," in Claudio Frischtak and Nathan Rosenberg, eds., International Technology Transfer: Concepts, Measures and Comparisons (New York: Praeger, 1985), 79.

53. For a comprehensive and authoritative account of the Dependency School's thoughts, and criticisms thereof, see: Magnus Blomstrom and Bjorn Hettne, The Dependency Debate and Beyond: Third World Responses (London: Zed Books, 1984). For a variety of views on, and case studies of technology transfer see: Claudio Frischtak and Nathan Rosenberg, eds., International Technology Transfer: Concepts, Measures and Comparisons (New York: Praeger, 1985).

54. Sanjaya Lall, "Trade in Technology by a Slowly Industrializing Country: India," in Frischtak and Rosenberg, op.cit.

55. Thomas Hatsichronoglou, "Indicators of Industrial Competitiveness: Results and Limitations," in Jorge Niosi, ed., Technology and National Competitiveness (McGill-Queens University Press, 1991), 189.

56. The duties of the state in the bargaining process for technology can be summarized in point form as follows: 1) to limit the restrictions placed by technology suppliers on access to technology and its subsequent use, 2) to ensure that the technology price tag is as close to a competitive price as possible, 3) to place a ceiling on royalty payments and technical fees and to reduce their duration, 4) to assure the inclusion of factors in the technology transfer package conducive to the successful assimilation of the technology, such as technical assistance, 5) to limit access to the domestic market in the FDI, 6) to ensure the domestic diffusion of the technology. United Nations, United Nations Conference on Trade and Development, "Transfer and Development of Technology in Developing Countries: A Compendium of Policy Issues," (UNCTAD/ITP/TEC/4), 1990, 50-58

57. As Niosi and Faucher point out "In company training...is not a sufficient substitute for this massive amount of state up-skilling, since it can only provide a complement for the sometimes unsatisfactory constituted labour force that suits the particular technological context and technical resources of enterprise. Industrial production and export competitiveness are directly affected by the national education strategy. Jorge Niosi, ed., op.cit., 133.

58. United Nations, United Nations Conference on Trade and Development, "Transfer and Development of Technology in Developing Countries: A Compendium of Policy Issues," (UNCTAD/ITP/TEC/4), 1990, 58-59.

PART

TWO

Case Studies

The State and the Development of the Microelectronics Industry in the Republic of Korea and Brazil

CHAPTER FOUR

Institutional Background: The State and Industrial Strategy

Introduction

A comparison of the national industrial policies of Korea and Brazil would reveal substantial differences that would have a strong bearing on the different objectives pursued by each nation in the formulation of technological strategies. Over time these differences have come to reside in particular industries and even in industry segments, not in entire sectors. With the growing globalization of industries, particularly high technology industries, these differences have become even sharper as national industries have become increasingly exposed to the global battle for competitiveness.

Differences in national competitive advantage arise due to disparities in the capacity of a nation's industry to upgrade itself over time. These in turn are a result of differences in national circumstances, such as government and corporate strategies, amongst others discussed earlier. Strategies are a means to an end embodying a consensus on the objectives to be achieved as determined by the historical and ideological factors pertaining to each nation.

Therefore, to carry out an analysis of the development of the microelectronics industry in Korea and Brazil, it is essential to go beyond a mere descriptive account of differences in competitive ability. The ability to reap the competitive gains derived from economies of scale, integration, technological

leads, etc., is not a cause but an effect. We know that some nation's firms are more competitive due to their technological superiority, differentiated product base or products which are more attuned to global market demand. The question we must ask is why. In essence what we are seeking to understand is the relationship between national industrial policy and the development of the microelectronics industry in Brazil and Korea, within the context of the concept of competitiveness.

To realize this we must distinguish between the different national approaches taken in regard to industrial and technological development which in turn requires an understanding of the role of individuals, enterprises and institutions, above all that of the state's. To this end an understanding of the historical context, with regard to economic and political factors, is essential; for it is herein that lies the answer to the crucial question of *why* national strategies differ. With this in mind I now turn to an examination of the state's role in Korea and Brazil from an evolutionary perspective

The Evolution of the Developmentist State: Ideology and the Rise of the Military in Brazil

Since independence in 1822 the mutually supporting ideas of "order" and "progress" have been steeped in the political and economic development of Brazil, serving as the country's dominant social and political doctrine. The most symbolic representation of this conviction is the Brazilian flag whose red and green insignia is underscored by the words "order and progress", thus firmly rooting the ruling dogma in the bastion of nationalism, at least in the

authoritarian nationalism embodied in the hearts and minds of the ruling classes.⁵⁹ The defining characteristics of Brazilian nationalism, perhaps its national identity, can be found in the social and geographical makeup of the country. Geographically Brazil encompasses a vast and highly diversified land mass (the fourth largest in the world and by far the largest in Latin America) stretching unbroken from the untamed Amazon in the north to the Rio de la Plata in the south, and from the Atlantic coast in the west to the foothills of the Andes in the east. The challenge of expansion and settling this vast rugged interior was a major factor in the development of a nationalist outlook based on establishing order and promoting progress so as to prevent any regression. Socially, or rather culturally, Brazil's most distinguishing feature is its language. It is the only country in Latin America where Portuguese prevails as the official language in a sea of Spanish speaking countries. While language and geography are amongst numerous other factors explaining the nature of Brazilian nationalism (discussion of other factors being beyond the scope of this study) they are the major ingredients in the explanation.⁶⁰ Indeed, the combination of a uniquely vast geography and language appear to be the most satisfying explanation for Brazil's overriding concern with national security given that the country has never been involved in any major international conflict or explicitly threatened by any of its neighbors. This may explain the predominant role which, as we shall see, the military plays in the social, economic and political life of Brazil, as the protector of national security; national security not in the limited sense of national defense, but in the much broader sense of national economic prosperity and political stability as defined by the military.

The perceived need for order and desire for progress gave rise to and found expression in the formation of centralized bureaucratic rule. While the

country's federalist constitution provided for a strong degree of regional autonomy, over the years the pendulum of power has increasingly tilted towards the federal government. The first dramatic swing in the pendulum occurred in 1930 with a military coup which brought to power the dictatorship of Getulio Vargas. The coup was a response to the effects of the depression of the 1930s which threatened to undermine the elites' dogma of order and progress.

Vargas's launching of what he termed the *estado nova* (the new state) in 1937 hailed the emergence of a highly centralized bureaucratic authoritarian regime with the teeth to enforce the ruling elites' objectives. To maintain order all political opposition was crushed and individual rights were superseded by the rights and interests of the collective as defined and pursued by the state.

To ensure economic progress the state became actively involved in the economic sphere of Brazilian life through the establishment of state owned enterprises particularly in areas considered vital to national security. These included industries such as iron and steel and trucks.

The most important outcome of the coup was the institutionalization of the military in the political sphere and thereby the economic sphere. Thus, the idea of progress, particularly the economic aspect of it, came to be associated with the military's overriding concern with national security dating back to early post-independence days. While Vargas was deposed by his own armed forces in 1945 and civilian rule subsequently restored, the military maintained a strong presence behind the political stage and made guest appearances at its own invitation.

Brazil's flirtation with democracy came to an abrupt end in 1964 when the military staged another coup, casting itself once again as the lead in the continuing saga of Brazil's political history. The primary factor in setting the

stage for the coup was, as in the previous one, a downturn in economic activity. The military viewing itself as the self appointed guardian of the nation's ruling tenets and national security, took to center stage once again and at its own discretion seized direct control of the reigns of power. Democracy was not to flower in Brazil for another two decades.

The military's latest coup established a clear correlation between economic downturn and military incursions in the economic and political life of Brazil. As alluded to above, the military's primary motivation for its actions was the protection of national security. National security had become virtually synonymous with the nation's economic prosperity; with the nation's ability to successfully and autonomously, through import substitution, chart the course of industrial development.

The Developmentist State: Protectionism and the Rise of Import Substitution in Brazil

The particular reasons for state intervention in the economy have varied over time, but the principal motivations, as alluded to above, have been to ensure the continuance of the dominant social and political tenets and in the same vein to ensure the nation's economic prosperity. Since the days of the Brazilian monarchy state counsellors and officials have "opted for protectionism, for government intervention, for not confiding in market mechanisms."⁶¹ It was not until 1930s, however, that the conceptual basis of Brazilian nationalism became explicitly intertwined with economic nationalism and still later, the early post war years, when the Brazilian state became committed to the process of

industrialization and industrialization became an end in and of itself.

The state's commitment to industrialization was to be achieved through import substitution, or rather through the general framework of an inward oriented industrialization strategy. The choice of such a strategy was the natural outcome of Brazil's overriding concern with national security which sought self sufficiency. The obsession with self-sufficiency itself was primarily the upshot of two factors. First, inherent in the concern with national security is the desire to steer one's own destiny, to be "maitre chez-nous". A second, and related point, is Brazil's sour experience with its export oriented agricultural strategy prior to the 1930s which unveiled its shortcomings in the depression of the 1930s as Brazil's export earnings dropped dramatically and the nation became exposed to the vulnerability of the international market.⁶²

The combined effect of these factors had a decisive impact on Brazil's assessment of integration into the global economy and its upshot the international division of labour. Full integration into the global economy was seen as a potential constraint to the state's ability to steer the course of industrialization and thus undermine national security.

Furthermore, the limitations on the state's ability, it was believed, would relegate Brazil to the bottom rung of the international division of labour as an exporter of primary commodities dependent on the industrialized countries for capital goods. The international division of labour was seen along the lines that Frobel et al. have described it; that is as a set of interwoven inflexible structures that are unsusceptible to national development strategies.

Within the framework of inward oriented development the state devised a number of policies and incentives to attain its objective. The most prominent of these was the creation and expansion of state enterprises whenever the private

sector seemed incapable of fulfilling the task. The most rapid expansion phase of the state sector occurred in the 1960s despite the Castello Branco's government's stated objective of rehabilitating the private sector. By the mid 1980s the federal government owned all telecommunications, electricity and gas utilities, the railways, all petroleum and coal production, the aircraft industry and two thirds of all steel production placing Brazil among the most statist non-communist countries. In financial terms, between the late 1960s and mid 1970s the state's share of the total net worth of the country's 100 largest firms grew from less than 60 percent to approximately three-quarters. In terms of invested capital the increase was from 37 to 45 percent. More state enterprises were created between 1970 and 1975 than during the preceding thirty years combined. It was also during this period that the state got involved in the microelectronics industry via the establishment of state owned enterprises that were to play a dominant role in the establishment and development of the industry. Consequently, as Esser notes

too little attention (was) paid to the functions which the private sector should perform in industrialization, in developing technology, and in exporting manufactures. This is particularly true with respect to the ... development of a small group of large, efficient, national companies with diversified production, innovative capacity, and financial management systems, which are instrumental in ensuring active integration into the world market and may come to resemble multinational groups...

As shall be seen in the following Chapter, the inadequate development of such enterprises has been one of the key deficiencies in the performance of the microelectronics industry characterized by poor export performance and inefficient production levels.

At approximately the same time that the state became committed to the process of industrialization, in the late 1940s, and early 1950s, there occurred

another significant event, an opening toward foreign direct investment (FDI). The country sought to industrialize quickly and FDI was seen as conducive to this goal. At the time the state was not so concerned with the potential threat that multinationals might pose to its sovereignty. So long as the multinationals increased the local content of production and thus assisted Brazil in industrializing, equity could remain in foreign hands. A prime example of this is the development of the automobile industry in Brazil.⁶³

The exception to the rule concerning the government's attitude towards FDI was in industries it considered vital to maintaining national security. These included the main utilities, petroleum and others cited earlier. The best example however is that of the telecommunications industry.⁶⁴ Generally, however, the state's disposition towards FDI was a fairly relaxed one. This stood in contrast to the many Brazilians, including some national business executives who were suspicious of the role of FDI.⁶⁵

In the early 1960s these feelings were still in the minority but they did not dissipate and instead continued to gather steam throughout the 1960s and 1970s. This was primarily due to, though not limited to two factors. The first was economic. In the late 1960s, early 1970s, as Brazilian companies began to come in to their own (developmentally speaking, in terms of size and industrial capability) their rivalry with the foreign firms increased and they became increasingly resentful of the power, resources and preferential treatment accorded to the latter, particularly as many began to feel squeezed out by the foreigners. The second factor was cultural in nature. As the presence of foreign corporations grew so did the fear of the *cocacolonization* of Brazilian society. Foreign corporations came increasingly to be viewed as bearers of alien values, particularly amongst the intelligentsia, and thus as a threat to Brazilian

traditions and the nation's cultural identity. Finally the growing presence of the multinationals, in terms of their economic power, began to even worry the government as to how to control these firms. Control, after all, is the essence of the ability to maintain 'order' and direct the process of industrialization.

In response to these concerns, the government's policies and the attitudes of national business toward multinational corporations began to change in the latter part of the 1970s. The result was the forging of more closely knit ties between national business and government. A prime factor behind the forging of the new relationship was the planned transition to democracy, which eventually took effect with the presidential elections of 1985. The government saw local capital as its best bet in the formulation of a strong conservative party that would serve as a bridge to carry over and ensure the continuation of its policies during and after the transition period to democracy and civilian rule. The alliance between the state and local capital was thus tightened at the expense of the multinational firms, supported by those who feared the foreigner for economic and cultural reasons.

It is important to note that the shift in government policy was in part, as in the past, fueled by an economic crisis. The crisis was sparked by the Arab oil embargo of 1974 which dealt oil-dependent Brazil's balance of payments and foreign exchange earnings a severe blow. The situation was further aggravated by Brazil's overspending on consumption and investment, a remnant of the economic boom years, which in 1975 outpaced domestic production growth by 7.8 percent. As oil and manufactured goods imports rose dramatically, 51 and 34 percent respectively, foreign debt hit a new high of \$21 billion and inflation soared to 30 percent.⁶⁶ As bad as these figures were, they were but a pale shadow of the astronomical debt and hyperinflation which were to confront

Brazil in the 1980s.

In response to these developments the government, as it had done under similar circumstances in the past, invoked the sentiments of nationalism, squarely placing the blame on external factors, which threatened to undermine the process of national industrial development. To redress the crisis the anti-dependency strategy of inward oriented development was reinforced which in turn bolstered the desire for self-sufficiency in science and technology. Import substitution was pushed on an expanded scale so as to decrease the nation's dependence on imports and thus ease the strain on the balance of payments. This goal also served as a pretext for deepening and diversifying the nation's industrial structure on an expanded scale which in turn was linked to the objective of self-sufficiency in science and technology. The closer alliance between state and local capital, cited above, was to become a pillar of the goal of self-sufficiency in science and technology fueled and characterized by a growing sense of industrial\technological nationalism.

As shall be exemplified in Chapter Five, in my discussion of the development of the Brazilian microelectronics industry, in the pursuance of the goal of self-sufficiency in science and technology considerations relating to existing capabilities were given short shrift. Within the context of Brazil's import substitution strategy the choice of industrial\technological development was almost always made on the basis of import demand which was then substituted by domestic production. If that sector happened to be of particular importance to national security then it was given higher priority and pushed on expanded scale. Considerations relating to existing production and technological capabilities were given scant attention as were considerations relating to market size. The chief concern was to attain a higher degree of autonomy in industrial

development so as to strengthen the nation's economic, political, and military security. Therefore Brazil strived to limit its reliance on foreign technology and foreign markets.

It was thus that Brazilian policy in regard to foreign capital became increasingly *Mexicanized*.^{66a} Increasing local content production was no longer sufficient. Economic decisions came to be increasingly rooted on the basis of ownership. Supported by local capital and those who feared the multinationals for cultural reasons, the government increasingly adopted and effectively implemented policies that favored firms whose equity was largely in the hands of nationals at the expense of those firms who were largely foreign owned. A number of subsidies were thus extended to majority owned Brazilian firms. These included favored tax treatment, subsidized loans from state banks and preferential treatment in obtaining government procurement contracts, amongst other measures. Perhaps most importantly, multinationals came to be cast in a biased shadow of suspicion that was to affect government decision making in a number of immeasurable ways.

The Brazilian Capital Goods Association gave its full support to the government as it believed that multinationals did "damage to the economy (by) taking up room that could be filled by a Brazilian company that was really developing its own technology".⁶⁷ It was clear that the spirit of nationalism was being invoked to protect local oligopolies and to mitigate increased competition.

As we shall see in the next Chapter, the most extensive application of the government's policies occurred in the microelectronics industry, whose formal inception coincided with the inauguration of the government's new stance.

Korea: The Evolution of the State

The beginning of the process of industrialization in Korea, and the evolution of the state's role in respect to it, can be traced back to the Japanese occupation period. Japan invaded Korea in 1905 just as Korea was coming into its own after more than five hundred years under Chinese tutelage. Under Japanese rule not only was much of Korea's traditional social and political structure maintained but in many instances it was reinforced. Native Korean traditions of hierarchy, loyalty and bureaucratic rule, derived from the edicts of Confucianism which had been transplanted into the country during its years under Chinese tutelage, were conducive to Japanese colonial rule and so they were strongly reinforced through such means as education, propaganda and the general operation of the Japanese colonial institutions. At the same time Japanese militarism injected in to traditional Korean structure a deep sense of discipline and desire for precision, efficiency, and the conscientious fulfillment of duty.

Above all, however, the most dramatic change was the rapid pace of industrialization and urbanization that took place under Japanese colonial rule, particularly after 1932 as Japan prepared for war. A process that had taken the industrialized countries of the West more than a hundred years was thus achieved in Korea in less than two decades. This mighty feat was based on a highly centralized system involving "a mighty trio of state organization, central banking and zaibatsu conglomerates...Much like its role in the decades after the Meiji restoration (in Japan), the state substituted for an absent, or at most incipient, entrepreneurial class".⁶⁸

The process, however, was marked by extreme discrimination, oppression and exploitation, arising out of Japanese assumptions of superiority.

The experience was to leave a deep mark in the Korean psyche, not only of indignation and hostility but more importantly of a strong determination to one day catch up with Japan to prove that they were not inferior, and thus restore the national honor. At the same time, however, Japanese influences in terms of both ideology and social structure were to play an influential role in the years to come.

In 1945, with the end of the war and the defeat of Japan, the American occupation force entered the southern half of Korea while the Soviets occupied the northern part. Efforts by the two occupying powers to establish a unified Korean provisional government became deadlocked and with the onset of the Cold War Korea became effectively divided at the 38th parallel.

The early years following the division of the country were of extreme hardship and instability for South Korea (hereafter Korea). Politically, the Japanese pullout had left a political vacuum that resulted in a power struggle largely reflecting the ideological struggle between the superpowers (the US and USSR). Economically, the division for the South resulted in a loss of important natural resources, such as coal, power generating stations and most important of all a heavy industrial base, all of which were primarily concentrated in the North.

The combination of these difficulties led to increasing reliance on the U.S. for both political and economic support. The U.S. saw its primary responsibility in the region as the containment of communism and lent its support to the far right anti-communist forces led by Syngman Rhee and backed by the very bureaucracy and police force which the Japanese had trained and installed during their occupation.

Rhee's autocratic regime (1948-60) was very much reflective of Korea's traditional political structure, including the aspects injected into it by the Japanese, as were the succeeding regimes of Chang Myon and Park. By building on the political and social order, the Americans provided the Korean leadership with a modern version of their hierarchical and authoritarian heritage. The continuity of this heritage was to greatly influence the future course of Korean development, particularly in serving to legitimize and render effective the role of the state in the economic sphere.

Two other phenomena of the American occupation period need to be noted: the growth of the military establishment and land reform. As a result of the Korean war (1950-53) the Korean army expanded over six-fold, from less than one hundred thousand men to more than six hundred thousand men out of a population of approximately twenty million. At the same time large numbers of Korean officers attended American military schools, in both Korea and the United States with emphasis on the study of military organization, administration, logistics and planning. After the war the program not only continued but intensified in an effort to make the Korean military more self-sufficient and efficient in light of the communist threat. By the late 1950s the Korean military

had more management skills, much greater discipline, and higher morale than the government bureaucracy or any other group in Korean society. Its approach was one of pragmatic problem solving, of achieving established objectives as quickly as possible by whatever means were available. Individual promotion depended on successfully carrying out assigned duties.⁶⁹

Under the Rhee regime South Korea's predominantly agricultural social structure underwent a major transformation which was to serve as the basis, and

thereby shape the future industrial development of the nation. The implementation of a series of land reforms, initiated in 1948 under the auspices of the American military government and completed a decade later, effectively abolished tenant farming and placed a three hectare ceiling on land ownership.⁷⁰

The land reforms had three major effects. First the three hectare ceiling made impossible the consolidation of land and the emergence of an agricultural system based on wage labour. This was of significant importance for two reasons. Firstly, by preventing the consolidation of land it provided for the major precondition for what was to be one of the most egalitarian industrialization processes amongst the developing countries, particularly in light of the tremendously rapid pace at which it took place. Secondly, and following from the first, it enabled the emergence of a much larger and integrated domestic market than would otherwise have been possible.

Second, the attractiveness of agriculture as a sphere for the accumulation of capital was lost, and thereby landed wealth was divorced from this sphere. Some of the wealthy landlords were compensated through government bonds which were exchangeable for shares in industrial enterprise. It is not surprising therefore to find that a number of the capitalists who partly financed the industrialization of the 1960s and 1970s were formerly wealthy landlords.

Third, the freeing of labour from the land cleared the way for urbanization on a mass scale, to which the Korean war added great impetus. The result was the emergence of a large urban proletariat. Thus, one of the basic conditions was established whereby landed wealth could be transformed into industrial capital using industrial wage labour. However, the budding capitalist class was as yet too small and inexperienced to be able to handle this transformation on its own.

The Rhee government's preoccupation with political problems prevented it from assuming the position of a catalyst for the country's industrial transformation. As such, the basis for a sustained process of industrialization failed to materialize under this regime. Although some economic growth did occur, based on import substitution, it mainly relied on American aid. Therefore, and not surprisingly, economic growth fell sharply between 1958 and 1960 as a result of cuts in US aid.⁷¹ In addition, what economic growth did take place was mostly wiped out by skyrocketing inflation resulting from the Korean war.

Economic failure largely due to the lack of a coherent development plan, and large scale corruption, combined with an educated urban class and the devastation wrought by the Korean war, led to an increasingly vocal urban opposition, stimulated and led by intellectuals, students and the mass media. After twelve years in power, the Rhee regime collapsed with his resignation on April 26, 1960, following widespread demonstrations, led by students.

The succeeding government formed by the Democratic Party under Chang Myon was ill fated for a number of reasons: its alienation from the military, which had gained considerable influence following the civil war, the military's alarm at student demands for reunification and the dismal state of the economy, the success of North Korea's economic growth which reflected badly on the South's dismal record, and finally the rise of left wing forces spurred by support from the North. The result was a successful military coup led by Major General Park Chung Hee and the establishment of a military government in 1961, until "democratic" elections in 1963 established a civilian government, also led by General Park.

Korea: Industrialization and the Developmentist State

It was not until after the military coup of 1961 that brought General Park to power that sustained economic development got underway in Korea. Despite the manner in which it came to power, the Park regime was greeted with acceptance and even relief by the majority of the population. It had become apparent to a substantial portion of the population "that only a strong man in charge of a united, disciplined administration could deliver the country from its precarious situation."⁷² Thus, national mobilization for development was met by an energetic popular response and facilitated by a strong work ethic inherent in Confucian thought.

Park's regime was very much in line with Korea's dominant traditional social and political heritage, successfully combining patrimonial authoritarianism with Japanese centralization and militarism, and the American belief in advancement based on merit. The bureaucracy, which was to become the government's economic arm, was thus revitalized into a highly structured, disciplined, efficient and pragmatic body.

Park's regime imposed on the country a heavy handed, top down industrialization strategy characterized by a high degree of planning and export oriented growth. The success of this strategy was due as much to the sagacity of the economic policies adopted as it was to the sustained pressure from the top for results and the efficiency of a revitalized bureaucracy. Economic planning was effectively carried out in accordance with military standards of discipline and efficiency acquired during the American occupation period and subsequently transferred to the administrative bureaucracy.

The ability of the state to effectively control and promote the course of

industrial development in Korea was directly linked to its control of the financial system. Between 1961, when the government began its takeover of commercial financial institutions, and 1980, virtually every aspect of Korea's financial system came under direct state control through public ownership. The need for this central control stemmed from Korean industries' heavy reliance on borrowed funds and the government's policy of promoting industrial accumulation. Through the control of the financial system the state sought to ensure that industrial capital would not become subservient to different needs and goals of financial capital. Moreover, control of the financial system provided the government with the means to ensure compliance on the part of business with its industrial policy and to reward and punish those firms accordingly. Korean industry's export success enabled it to attract large amounts of foreign capital, but this too was allocated under strict government control through preferential loans to favored firms in favored industries. While the state regularly consulted and collaborated with business, its control of the financial system left no question as to who was running the show. The business class, lacking a long or respected social tradition, tended to be pragmatic opportunists, adapting to whatever policies that promoted profits. In doing so businesses were rewarded in the form of tax breaks, loans and other incentives.

The rapid growth of the Korean economy began with the rapid growth of exports, due to a shift in emphasis from an industrialization strategy based on inward looking import substitution to an outward oriented export substitution strategy. Lacking abundant natural resources and recognizing the limitations of its domestic market, in regard to size at the time, Korea saw export oriented growth as its best bet in jump starting the process of industrialization. In contrast to Brazil the upshot of integration into the global economy, the international

division of labour, was seen as a fluid changing process responsive and conducive to national development strategies.

Rapid export growth based on labour intensive industries, and the ensuing employment creation, played a role in stimulating development without substantially worsening the distribution of income. As labour surplus became absorbed and real wages began to rise, it was also possible to raise farm prices so that all elements of the population benefitted from growth. The rise in real wages over the years was accompanied by a relatively equitable distribution, which stimulated the development of an integrated domestic market. As noted in Chapter Three, this was a key factor in the development of innovative capacities upon which Korea was to become increasingly reliant in the 1980s as its labour cost advantages began to erode.

The inauguration of this strategy was accompanied by an array of policy reforms, such as exchange rate devaluations and export subsidies designed to support it. Successful exporters not only made large profits but were also awarded presidential medals. Indeed it was a hallmark of the government's military discipline and efficiency to allow unsuccessful and/or uncooperative firms to fail or to force them to merge with larger successful firms. This encouraged the growth of oligopolistic firms, known as chaebols.

While Korea's rapid growth depended in large part upon export expansion- from \$50 million worth of goods, mainly composed of primary products in 1962, to \$50 billion, 94% composed of manufactures in 1982-73 import substitution was never abandoned as a viable industrialization strategy. Import substitution was promoted on a very selective basis in the 1960s and on an expanded scale in the 1970s in conjunction with the development of heavy industries such as defence, chemical and iron and steel.

2

PM-1 3½" x 4" PHOTOGRAPHIC MICROCOPY TARGET
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The simultaneous pursuance of export expansion resulted in a contradiction in that Korea became increasingly more import dependent during this period despite the retention of import substitution. This contradiction reveals a fundamental point. Korea's industrialization has not been based on export substitution per se. It has been based on a policy of outward oriented growth, in which export expansion is not seen as an end in itself, but as a means to the acquisition of foreign exchange and technology that would enable the importation of essential inputs for the development of a self-sustaining industrial and technological core.

The expansion of import substitution in the 1970s was carried out by large conglomerate corporations, the chaebol. A chaebol is comprised of a wide variety of economic activities ranging from manufacturing, to services, to construction- all under the supervision of either the founding entrepreneur or his descendants. Throughout the 1960s and 1970s the government's policy of channeling preferential loans to favored firms in favored industries contributed to the spectacular growth of the chaebols. In 1984 the top thirty chaebols accounted for approximately one-third of all sales. The chaebols' size and resources have been important factors in their ability to attract more highly qualified personnel, acquire more advanced technology, build larger and more modern plants, invest substantial sums in research and development and training, and pay better wages than other smaller firms. These abilities, as shall be seen in Chapter Five, are consequential to the explanation underlying Korea's success in the microelectronics industry.

Throughout the 1960s and 1970s foreign direct investment played a minute role in Korea's industrialization process. During this period foreign direct investment was regarded with a certain degree of animosity, due to fears

that it could undermine the development of a self sustaining industrial core and so was tightly regulated. Employing a "positive list" system all areas were considered closed unless otherwise stated. In addition, FDI was subject to a rigorous screening process, taking into account considerations such as management control, the balance of payments, technology transfer and employment amongst others things. The government also insisted that multinationals be export oriented so that they would not undermine the growth and development of domestic firms.

As a rule the government has shown a clear preference for joint ventures, in the belief that they are more conducive to the transfer of technological know how and training of personnel. By the end of 1978 close to 58 percent of cumulative FDI was in joint ventures.⁷⁴ Overall, however, between 1969 and 82, FDI accounted for only 1.2 percent of gross domestic capital formation.⁷⁵

However, beginning in the late 1970s and early 1980s the government's policy in regard to FDI, indeed in regard to industrial policy generally took a turn, at least formally, towards liberalization. With the assassination of General Park in 1979 and the onset of the 1980s Korea entered into a new era. The ascendancy of a more democratic political process and a growing trade surplus sparked calls for economic liberalization from both within and without particularly by the US.⁷⁶ Moreover, the economic recession of 1979-82, sparked by the 1979 oil price increase, combined with the political and economic disruption following Park's assassination, had made it clear that the economy was now far too complex for the kind of centralized decision making that had been practiced in the past. The government was by no means about to abdicate its position at the helm of economic decision making, but it was convinced that

the reins would have to be loosened. Rather than give direct orders to industry it would now rely primarily on preferential subsidies to achieve its aims.

The shift in government thinking was reflected in its re-emphasis on export expansion, liberalization of policies governing FDI and less support for the chaebol. By 1979 the effects of the emphasis on import substitution throughout the 1970s were bearing heavily on the Korean economy.⁷⁷ Korea's dependence on imports during this period had resulted in a rapidly rising foreign debt which in turn had fueled an inflation rate hitting the 35 percent mark.⁷⁸ To counter these effects, policies supporting export expansion, such as currency devaluations and export subsidies were pushed at an accelerated rate. In the ensuing years the rapid rate of export expansion resulted in the rapid accumulation of foreign reserves and helped to considerably reduce the foreign debt/export ratio. The expansion of export earnings also stimulated the growth of domestic demand and real output.⁷⁹ Moreover, as part of the policy of export expansion firms were encouraged to branch out overseas in the OECD markets as a means to penetrate the rising shields of protectionism in regard to imports and technology transfer.

At the same time policies governing FDI and imports were relaxed partly as means to appease calls, particularly by the US, to reform its trade regime and thus reduce its trade surplus and partly as means to make the Korean economy more competitive, through increased competition and greater inflows of foreign technology. To this end a "negative list" system was adopted in regard to FDI, in which most areas were considered open subject to review and foreign import controls were relaxed.

In regard to domestic firms, government support of the chaebols began to soften as a means to correct oligopolistic imbalances in the domestic economy

and encourage greater competitiveness. At the same time the growth of small and medium sized firms was encouraged, while weak, badly managed or uncompetitive firms were allowed to go under or forced to merge with favored firms. Generally however, a more moderate stance has been adopted involving consultation and collaboration with industry as opposed to the old approach of bureaucratic control. The chaebols are relatively free from discretionary government intervention and are increasingly being encouraged to go their own way.

As part of its loosening stranglehold on industry the government also undertook to liberalize the financial system, its most powerful tool in its control of the economy. To this end banks have been permitted to set their own interest rates within prescribed limits and have also been given a greater voice in deciding to whom to lend. Foreign banks have also been given some leeway to establish branches.

While the government has made some inroads in the pursuit of liberalization objectives, it has done so half-heartedly. In some areas it is more a case of lip service than action. For example, despite its stated objective of favoring a freer financial system, it continues to exercise ultimate control over the distribution of funds. In regard to the chaebols, the government's objective of limiting their expansion has met with little success. The close relationship that has been fostered over the years between bureaucrats and the chaebols' executives has been a primary factor in mitigating the government's objective. Equally important, if not more so, is the realization on the part of the government that the chaebols are the backbone of Korea's industrial success and that future growth and development will depend upon them for some time to come. The global outlook of the chaebol will continue to be a key factor in

Korea's bid to maintain and increase its access to the markets of the OECD countries and in its efforts at obtaining advanced foreign technology.

The beginning of the liberalization period coincided with, and was stimulated by, a strong urgency for the restructuring of the Korean economy based on a higher level technological intensity, involving the development of capabilities in high technology industries such as microelectronics. The dawn of the 1980s saw the beginning of the sunset for many of Korea's traditional labour intensive, low value added industries. Rising wages in Korea were making it increasingly difficult for Korea to maintain its low cost advantage in light of the greater cost advantage of the second tier Asian and Latin American NICs. It thus became evident that if Korea was to maintain its competitive advantage and thereby preserve its position in the dynamic growth pole of the world economy it would have to enter the realm of high tech, high value added industries in which competitive advantage is based on innovative capability. It was within this context that Korea's formal and aggressive foray into the microelectronics got underway.

Conclusion and Prelude to Case Studies

In the foregoing pages I attempted to delineate, from a historical perspective, the factors that underlie the different industrial/technological strategies pursued by Brazil and Korea. In both Korea and Brazil the ultimate goal has been to attain a greater degree of technological autonomy. The crucial difference between the two, however, lies in what has been the motivating factor in the pursuit of this goal. As outlined above, in Brazil the quest for

technological autonomy has been driven by national security concerns shaped by unique national circumstances as reflected in its ideological, socioeconomic, and political orientations. In contrast, in Korea the quest has been driven by the need for enhancing national competitiveness in the global market and the strategy pursued has likewise been shaped by its unique national circumstances. The establishment of a strong national presence in the global market has been the overriding national security concern. This concern can be partly attributed to the nation's desire to restore its honor in the face of the Japanese and to counter the North Korean economic and political dogma.

In the late 1970s, and early 1980s, both Korea and Brazil were confronted with similar economic crises, characterized by high inflation and foreign debt caused primarily by high imports. Their response to the crisis, however, differed considerably. Brazil took the inward oriented path and re-emphasized its policy of import substitution. To this end self-sufficiency was stressed in national industrial and technological development and consequently a highly conservative stance was adopted in regard to technology transfer and foreign direct investment (FDI). Korea, on the other hand, took the outward oriented path and encouraged globalization. Concomitantly, and as a result, regulations governing FDI and imports were liberalized and a progressive stance was adopted in regard to technology transfer with the goal of making the nation more competitive in the world market. In both cases the same line was taken with regard to technological policy. As the foregoing pages have attempted to demonstrate the choice of strategy was in both cases largely a product of different historical circumstances as shaped by different ideological, economic, and political factors.

The choice of strategy has in turn influenced each nation's conception of

the costs and benefits of integrating into the global economy and its upshot, the international division of labour. Korea has viewed integration into the global economy as beneficial. It has not viewed the international division of labour as a given rigid structure but rather as a changing process, shaped by the interaction of national policies, through which it can effectively achieve its industrialization objectives.

Brazil, on the other hand, has viewed full integration into the global economy with grave reservations. It has tended to view the global division of labour more as a structural constraint that could undermine the ability of the state to steer the process of industrialization and hence, by extension, its ability to safeguard the nation's security.

In both cases the state has played a prominent role in the process of industrial development. The pattern of state intervention, however, has differed considerably in accordance with the choice of industrial strategy. In the case of Brazil's import substitution strategy, considerations relating to existing production and technological capabilities are given scant attention as are considerations relating to market size. The chief concern has been to attain a high degree of autonomy in industrial development so as to strengthen the nation's economic, political, and military security. Therefore Brazil has strived to limit its reliance on foreign technology and foreign markets.

By contrast, in Korea new industries are primarily, though not exclusively, targeted for development on the basis of existing capabilities; that is on the basis of industrial extension. In doing so the primary concern has been the enhancement of the nation's competitive standing in the global economy. This concern has transcended concerns of self-sufficiency and has led Korea to rely heavily, in contrast to Brazil, on foreign technology and foreign markets.

As shall be seen in the next chapter, the different path taken by each nation has had a strong bearing on the different strategies pursued by each nation in the process of developing their respective microelectronics industries. The essence of the argument that shall be developed in the pages to come is given below.

In the case of Brazil's microelectronics industry I will attempt to show that its development has from the start been guided by political and national security concerns at the expense of explicitly economic factors. Subsequently, I will argue that this blinded the state to economic factors such as market conditions, scale economies and the exploitation of export opportunities. Moreover, it led the state to misjudge the manner and timing of the implementation and length of protectionist policies designed to nurture the development of the industry. Thus, the state's blinkered outlook has resulted in the development of an industry that is at odds with global industry characteristics, as set out in Chapter Two, in terms of vertical integration, R&D resources, technology acquisition and global strategy and therefore uncompetitive.

In Korea, however, it was economic considerations that were at the forefront of policy making in regard to the microelectronics industry. The industry's development was based upon existing capabilities in the consumer electronics industry and was in essence a case of industrial and technological extension. Policies, including protectionist policies such as market reserve, to nurture the industry's development were designed and implemented in accordance with national capabilities and global industry standards as dictated by the nature and pace of technological change occurring globally. Consequently, from a global perspective the Korean industry is in a much

healthier position in comparison to the Brazilian industry. At the time, however, the industry's shortcomings, most notably its lack of design capabilities leave room for it to take a lesson from the Brazilian experience in terms of paying greater attention to the development of in-depth indigenous technological capabilities.

In exploring this argument in the following Chapter the questions which shall be addressed are as follows: 1) What were the motivating factors and national circumstances which prompted the inauguration of the industry? 2) What strategic framework was adopted and why? 3) Within the chosen strategic framework what specific policies were adopted and why, 4) How were the former implemented? and, 5) How effective have the respective strategies been in the development of a globally competitive and sustainable industry?

The last question goes directly to the issue of assessment. This shall be carried out in reference to 1) the global structure and pace of technological change characterizing the industry, as discussed in Chapter Two; 2) the nature of competition as dictated by the pace and nature of technological change, as discussed in Chapters Two and Three; and, 3) the role of the state and national firms in regard to the former as set out in this chapter.

Given the increasingly heavy involvement of the state in strategic industries, particularly in the NICs, the analysis shall accordingly focus primarily on the role of the state.

Notes (Chapter Four)

59. Jorge I. Dominguez, "Order and Progress in Brazil," in George C. Lodge and Ezra F. Vogel, eds., Ideology and National Competitiveness (Boston: Harvard Business School Press, 1987), 241.

60. Bradford Burns Nationalism in Brazil: A Historical Survey (New York: Praeger, 1968), 4-11.

61. Dominguez, 255.

62. It should be noted that Brazil's sour experience with the international market was in good part due to the uniformity of its exports, primarily agricultural commodities. The more diversified a nation's export portfolio the less vulnerable it is to the exigencies of partaking in the international market.

63. For an account of the development of the Brazilian automobile industry see: Carl J. Dahlman, "Foreign Technology and Indigenous Technological Capability in Brazil," in Martin Fransman and Kenneth King, ed., Technological Capability in the Third World (London: Macmillan, 1984), 317-334.

64. For a thorough account of the Brazilian telecommunications industry see: Mike Hobday, "The Brazilian Telecommunications Industry," in Development and Change March, 1984.

65. Dominguez, 261.

66. Ching-Yuan Lin, Latin America vs East Asia: A Comparative Development Perspective (New York: M. E. Sharpe, 1989), 95-6.

66a. Dominguez utilizes the term *Mexicanized* to refer to the reorientation of government decision making regarding industrial development based on the ownership structure of particular firms. The reorientation favored majority owned Brazilian firms which consequently received

preferential tax treatment, discounted interest rates from state banks, and preferential access in their sales to state enterprises and other agencies. By 1977 Brazil's National Economic Development Bank (BNDE) and the Industrial Development Council (CDI) were aggressively implementing policies to bolster national industrial firms and to deny comparable opportunities to foreign firms.

The quotation is from Dominguez, 262.

67. Dominguez, 263.
68. Bruce Cummings, "The Origins and Development of the Northeast Asian Political Economy: Industrial Sectors, Consequences," in Frederick C. Deyo, ed., The Political Economy of the New Asian Industrialism (Ithaca: Cornell University Press, 1987), 54.
69. Vincent R. Brandt, "Korea," in George C. Lodge and Ezra F. Vogel, eds., Ideology and National Competitiveness (Boston: Harvard Business School Press, 1987), 218.
70. Paul Kuznets, Economic Growth and Structure in the Republic of Korea (New Haven: Yale University Press, 1977), 47.
71. Hagen Koo, "The Political Economy of Income Distribution in South Korea," in World Development, Vol.12, 1984, 1031.
72. Brandt, 219.
73. Larry E. Westphal et al., "Export of Capital Goods and Related Services From the Republic of Korea," World Bank Staff Working Paper, no. 629, 1984, Abstract.
74. Clive Hamilton, Capitalist Industrialization in South Korea (Boulder: Westview Press, 1986), 45.
75. Ibid.
76. "Big Business on the Move," South Survey, September 1988, 80.
77. Import substitution regimes have a tendency to reinforce import dependence over the run for a number of reasons. Two of these are of significance in explaining why Korea's import dependence increased despite the emphasis on import substitution. One, import substitution in some industries stimulated rising incomes that were biased towards imported goods and many of the import substituting industries themselves required imported inputs. Two, and more important, is that overvalued exchange rates, which are a hallmark of import substitution regimes, encouraged the use of imported inputs especially those on which duties are low. For a thorough account of how import substitution can increase a nations import dependence see: Malcolm Gillis et al, Economics of Development 2nd edition. (New York: W.W. Norton and Company, 1987), 442-453.
78. Brandt, 223.
79. Lim Youngil, Government Policy and Private Enterprise: Korean Experience in Industrialization (Berkeley: University of California Institute of East Asian Studies, 1981), 120-121.

CHAPTER FIVE

Case Studies

The Development of The Brazilian Microelectronics Industry

Introduction

Unlike the rest of Latin America, where the lack of consistent backing has resulted in a failure to develop a coherent long-term microelectronics policy, in Brazil the advent of a microelectronics industry has been accompanied by consistent and sustained state backing. The motivations for doing so have generally been in line with Brazil's national ideology based on a doctrine of national security and a desire for national sovereignty. The state's active role in spearheading the development of an informatics industry can be linked to the virtual absence of the private sector in the initial efforts to develop an informatics industry. This, as Katz notes with respect to the informatics industry, is the result of the "Brazilian private sector's tendency to invest in areas of low risk and short term return on investment- leaving the state to invest in those areas that required large amounts of capital and provided only gradual return on investment over the long-term."⁸⁰ At the same time the state's traditional predisposition to get directly involved, through public ownership, in strategic industries considered vital to national development and security, has

been a decisive factor in the state's pioneering and unrelenting role in this sector.

In the ensuing pages I intend to examine the state's role in the establishment and development of the microelectronics industry with respect to its motivations and goals. In the process I hope to show how the overly nationalistic agenda behind the state's objectives blinkered its outlook to explicitly economic considerations such as domestic market conditions and technological capabilities. Subsequently, in my assessment of the industry and state policies, I will strive to demonstrate how this blinkered outlook has hampered the competitive capacity of the industry with respect to global industry trends such as scale economies, vertical integration and globalization.

Background: Fusion of Interests

In the late 1960s and early 1970s the Brazilian computer market ranked the twelfth largest in the world with a robust, to say the least, annual growth rate in the range of 30 to 40 percent, thanks primarily to the Brazilian government's growing data processing needs. The market's dynamism attracted a number of multinationals, primarily American, and it was not long before they came to dominate virtually every aspect of the market. IBM had the largest share of the market with Burroughs a not too distant second. By the early 1970s these two companies had established substantial manufacturing operations in Brazil, and other foreign firms such as Digital Equipment and Honeywell were seriously considering doing likewise. The existing manufacturing operations, however, were geared primarily to product assembly and no R&D activity worthy of mention was carried out by these firms. At the same time a number of

other foreign, non-American, firms, such as Olivetti, Ferranti, NCR and Phillips were actively selling in the market. However, virtually all the firms including the two largest imported more than they exported.⁸¹

It was within this market context that in the early years of the 1970s the first government directive appeared regarding greater autonomy for the country in the field of microelectronics. This concern appears in the first National Plan for Development, covering the period 1972-74 and in the first basic plan for scientific and technological development for the period 1973-74. The prime mover in the initial creation of a Brazilian microelectronics industry was the combined interest of the Ministry of the Navy, whose interests were represented by naval officer Luis Guarnay, and the National Economic Development Bank (BNDE), whose interests were represented by Jose Pelucio.⁸²

The Navy's interest in the development of indigenous capabilities in this area arose out of its concerns with national security which at the end of the 1960s prompted it to modernize its armada. This involved the purchase of six highly technologically sophisticated frigates from the British firm Vosper. The frigates were each fitted with highly sophisticated real-time computers that controlled their navigation and firing systems, supplied by the British defense electronics firm Ferranti. The system's maintenance requirements, however, were beyond the navy's abilities. For the navy, and the military establishment in general, this clearly alluded to the cold fact that the rapid pace of technological progress brought on by microelectronics would serve to undermine the country's national security. Thus, there developed in the military establishment a sense of urgency, sparked by the navy's needs and concerns, for the development of indigenous technological capabilities in the field of microelectronics.

At the same time a similar sense of urgency was developing at the

BNDE arising out of economic concerns. The BNDE, a highly nationalistic and entrepreneurial state institution, was becoming increasingly concerned with the need to diversify and upgrade the country's industrial structure so as to lessen its dependence on foreign technology which it believed was increasingly undermining the nation's sovereignty.

In 1971 these two interests came together in the form of a Special Working Group, GTE (Groupe de Trabalho Especial) Funtec III, which came to be known informally as the Guarnay Project, with a budget provided by the BNDE of \$2.0 million. Both the BNDE and the navy agreed that Funtec should focus on the development of minicomputers as opposed to medium or mainframe computers. Minicomputers were considered to be within Brazil's technological competence and they represented a segment of the market in which the presence of multinationals was relatively weak.

However, the navy and BNDE disagreed as to the type of minicomputer that should be manufactured. In line with its needs and concerns the navy believed that the industry should be oriented towards the development of real time industrial process-control computers. The BNDE on the other hand believed that such an approach might undermine the economic viability of the venture. Instead, it favored the development of business computers oriented towards the commercial civilian market. An agreement was finally struck with the decision to establish two ventures, one to produce process control computers for the navy's needs, COBRA, and another called BRASCOMP, to make minicomputers for the commercial market. On the navy's insistence COBRA was to be launched first.⁸³

Both companies were to be based on a *tripe* model, a partnership involving the state, a private domestic firm, and a foreign multinational.⁸⁴ The

last was absolutely necessary for obtaining the required technology and proved to be one of the most difficult aspects of the venture. Most multinationals were unwilling to divulge their highly guarded technological knowledge in the belief that it would undermine their operations or insisted on conditions that the Brazilian government found unacceptable. In COBRA's case a deal was finally struck with Ferranti, whose primary motivation in joining the partnership was to maintain its lucrative relationship with the navy. Ferranti's principal role was to be limited to that of technology transfer in exchange for a one-third stake in the venture. As for the private local partner the search proved to be even more difficult given Brazil's limited capabilities in microelectronics technology. After much search EEE (Equipamentos Electronic) was chosen for a one-third stake in the company.⁸⁵ Finally the state's one-third share was represented by DIGIBRAS, a state owned holding company primarily under the control of the BNDE and used by it as a conduit for the transfer of funds and market and technical information to national computer firms. DIGIBRAS was to oversee the operations of BRASCOMP also, for which the tentative foreign partner was to be Fujitsu.

From the date of its inception in July of 1974 COBRA ran into trouble. The navy's plans for COBRA proved to be too far reaching technically, given Brazil's technological capabilities at the time, and the costs involved were beyond the navy's means and considered too risky and unfeasible by BNDE. Thus the navy's plans for COBRA were heavily downgraded and it was decided that COBRA's focus should be re-oriented towards the civilian minicomputer market and also provide for the military's down-sized needs. With COBRA's new mandate, plans for BRASCOMP were abandoned and the company never materialized.⁸⁶

Despite COBRA's initial failure it succeeded in two important respects. First, it succeeded in raising national awareness in Brazil in regard to computers and informatics technology in general, particularly amongst national business upon which, as we shall see, much of the industry's future growth was to depend. Second, it got the ball rolling in regard to indigenous R&D effort and the development of the appropriate human capital both of which were in critical shortage.

Informatics Policy: CAPRE, SEI, and Market Reserve

Parallel to Funtec's efforts to develop a national informatics industry the Brazilian government took what was to become its most decisive step in the development of a Brazilian informatics industry with the formation of the Commission for Electronic Processing Activities (CAPRE) in 1972 under the direction of the Secretariat for Planning. CAPRE was originally created to stem the tide of computer and related equipment imports and thus alleviate the pressure on Brazil's budget deficit. Its primary role was to regulate the country's computer imports and to this end to rationalize the government's computer purchases.

It was not long, however, before the "ideological guerillas"⁸⁷ who staffed CAPRE realized that their position as the St. Peter of the informatics industry effectively placed them in the position to create an informatics policy and regulate and nurture the development of the industry accordingly. The government also realized the pivotal role that CAPRE could play in this regard given its strategic positioning. Consequently CAPRE's powers were expanded

by the government in 1975 beyond the regulation and limitation of imports to actively supporting and fostering the development of an indigenous informatics industry.⁸⁸ In July of the following year CAPRE announced its first comprehensive policy for mini-computers and auxiliary equipment. The primary objectives of CAPRE's anti-dependency market reserve policy were as follows:

- To reduce the country's dependence on foreign technology.
- To encourage the application of locally developed technology.
- To encourage the development of technological capability that would enable the domestic production of informatics products. This in turn was seen as a means for enhancing the national cultural and political life thus reinforcing national identity and sovereignty.
- To ensure national corporations play a predominant role in the national informatics market.
- To ensure national control of production of information resources.⁸⁹

To achieve these objectives a policy of market reserve was adopted in regard to the minicomputer segment of the market which effectively barred foreign firms from competing in the mini-computer segment. This was in addition to its directive concerning import controls on informatics products. Moreover, preferential government procurement contracts were adopted as a means to encourage the entry and early sustainment of domestic firms. The rationale behind CAPRE's policy was a direct offshoot of the infant industry argument.

Meanwhile COBRA's initial attempts at industrial ground breaking in the sector proved to be a commercial failure. Given the technological superiority, economies of scale and overall economic advantage enjoyed by the multinationals it failed to win any share of the private market. Its survival was based entirely on a life support system provided by the state, involving government procurement and continuous injections of funds from BNDE, without which it would most certainly have withered away. Under these

circumstances the private partners were unable to sustain the large start up costs given the long and uncertain return on investment expected. Disillusioned by what it considered to be the economically unfeasible goals of the navy and subsequently by the venture's lack of commercial success, EEE threw in the towel hanging on to a mere 4.5 percent equity. Thus DIGIBRAS' share rose to 65.3 percent while that of Ferranti's increased marginally to 39.1 percent. However, it was not to be long before Ferranti, also disillusioned with the company's success, also decided to bow out of the venture. In the end the state, DIGIBRAS, was largely left alone.⁹⁰

With IBM's announcement in 1976 of its plans to introduce its powerful new system 32 mini-computer into the market, COBRA and for that matter the entire Brazilian informatics industry appeared to be going over the water fall. The flow of events, however, was suddenly reversed when CAPRE announced its informatics industry plan.

Despite strong pressure by IBM at the highest levels of government, involving a lucrative offer of producing high quality, low cost, locally manufactured minicomputers, production of the system 32 computer was forbidden and IBM was effectively barred from the mini-computer market. This was a clear reflection of the resolve by the cadre of 'ideological guerillas' at CAPRE to bring to fruition a national informatics industry and their ability to withstand the power and resources of the multinationals. Ironically, IBM's heavy handed approach served to enhance the unison and determination of the CAPRE technicos to push COBRA as a national champion of minicomputers. Moreover, the decision reflected the government's intention that the informatics industry not develop along the lines of the automobile industry where local equity and national autonomy were sacrificed for the sake of local content production.

Having won its first decisive battle with the multinationals, by barring IBM from the mini market and thus maintaining the integrity of the market reserve policy, CAPRE immediately went about rejuvenating COBRA. A major aspect of CAPRE's mandate was to raise the awareness of local capital to the benefits of computer technology. Thus, in 1977 CAPRE managed to bring together a consortium of eleven banks, including some of the nation's largest, to invest in COBRA prompted by their newly realized need for an electronic automation system. The consortium acquired a 39 percent stake in COBRA, left vacant by Ferranti's pullout, in addition to which BNDE invested \$3.3 million and gave COBRA guarantees for foreign loans in the region of \$1.3 million. Finally Digibras, now with 61 percent equity, contributed \$1.5 million.⁹¹

The Brazilian informatics industry was finally taking off. What remained however was to get local private capital involved in manufacturing. To this end a competition was set up whereby three domestic firms were to be selected to manufacture mini-computers and sell them in the reserved Brazilian market. The selection criteria were as follows:

1. Priority was to be given to firms which utilize local technological resources to design and develop computer products. Local firms would be allowed to purchase the required technology from a foreign company providing the purchase was limited to four to five years. Subsequent models would have to be developed locally. In essence technology transfer was to be a once and for all deal after which local firms would be required to rely on their own capabilities.

2. The minicomputer firms were not allowed to diversify into the production of computer products, but had to concentrate on the central processing unit, leaving to other companies the manufacture of peripherals and all other computer products. The purpose of this requirement was to avoid

excessive market concentration as existed in the large and very large segment of the computer market, dominated by multinationals, where a single firm IBM accounted for 70 percent of the market.

3. The utilization of locally manufactured components to the extent possible.

4. The development of standard interfaces so as not to fragment the market and encourage the utilization of locally manufactured components.

5. Firms in which equity was majority or preferably all Brazilian would be given priority.⁹²

All in all sixteen firms took part in the competition. Seven were wholly owned subsidiaries of multinationals, two were joint-ventures and seven were wholly owned Brazilian firms. Neither of the two joint-ventures was with a major computer multinational. As Evans notes, they chose instead to "submit proposals for wholly-owned operations, apparently counting on the technological and economic superiority of their proposals to override considerations of local equity participation and local absorption of technology."⁹³ In the end, however, the day was won by three wholly owned Brazilian firms who won the rights to manufacture minicomputers. The decision was yet further proof of the government's resolve, particularly that of CAPRE's, and the extent to which the multinationals had failed to assess the force behind this resolve.

The three firms who won the competition, SID, Labo and Edisa, were all, as in the case of COBRA, backed to a considerable extent by leading financial institutions.⁹⁴ Later, CAPRE approved a fourth company, Sisco, to produce minicomputers. It too had strong financial backing, from Henry Maksoud, one of Brazil's leading financiers.

The Technological Abertura: Growth, Demise and Rebirth

With the selection process over and the market reserve policy in place local private capital obtained a clear economic stake in the Brazilian informatics industry. The national champion, COBRA, however, remained as the vanguard of the national industry. The combination of cash and a secure market, provided by the banks who had stake in the company, set the stage for COBRA to flourish. In 1977 COBRA signed a technology transfer agreement with the U.S. firm Sycor for a new line of mini-computers, the 400 series, specifically designed for the banking industry's data entry needs.⁹⁵ The 400 series was to be the first line of computers designed completely in Brazil using 92 percent locally developed components.

By 1978 COBRA had established a new and expanded 10,000 square meter plant and increased its employment by three fold to approximately 2000. Orders began to pour in from the banks for as many as 700 of the 400 series computers.⁹⁶ While the computers were more costly and slightly less advanced than those offered by the multinationals, the banks believed it to be in their best interest to pay the higher price than the alternative of sinking more money in COBRA. The arrangement was in COBRA's best interest also as it enabled it to deepen its technological capability by moving up the learning curve through increased production. It was not long before COBRA introduced its more powerful 500 series mini-computers. The private sector while still lagging behind COBRA appeared to be meeting with some degree of success also.

Amidst this apparent success, however, signs of trouble were beginning to emerge. The minicomputer's technology was fast becoming obsolete and uncompetitive. The technology's erosion was due to a number of interrelated

factors. First, the unwillingness of the American computer manufacturers to license the mini's technology had seriously undermined the technology's diffusion and use. As a result the technology was becoming highly uncompetitive. Second, the Brazilian minicomputer manufactures had remained bound to the technology they had originally acquired and had failed to make the transition to the supermini technology based on the 32 bit processor as opposed to the 8 bit technology of the mini system. Domestic firms clearly did not have the capability nor the financial resources to keep up with the pace of technological change. Apparently CAPRE's ideological blinkers, its preoccupation with self-sufficiency, had led it to overestimate the technological capacity of domestic firms. CAPRE's insistence that domestic firms develop in depth capabilities in a generation of products that was becoming fast obsolete was to widen the technological gap of the domestic industry, vis a vis the advanced industrialized countries, and thus impair its competitive capacity. Further evidence of CAPRE's blinkered outlook is provided by the advent of the microcomputer, a development which it had failed to anticipate.

The advent of the microcomputer, based on Intel's 8 bit microprocessor technology, was the most decisive factor in the demise of the 8 bit mini system's technology. The microcomputer was not only as powerful as the mini but it was priced below the former also. The fast paced diffusion of the micro's technology was primarily due to the nature of the firms that pioneered the technology. Firms like Intel, Motorola, and Zilog were merchant firms dedicated to the production of microprocessors. Thus, microprocessors, as Evans explains "were available on a merchandise basis rather than being incorporated in final products as proprietary technology."⁹⁷ This fact, as shall be seen shortly, was to be of great significance in the development of the Brazilian microcomputer

industry.

This turn of events clearly revealed the informatics policy's lack of foresight based on miscalculations regarding the nature and pace of technological change. The root of the problem of miscalculations was that the informatics policy was from the beginning driven by political factors, such as sovereignty and national security, as distinct from economic factors such as efficiency. This clearly brings into question the pragmatic character ascribed by Adler to the 'ideological guerillas' that staffed CAPRE and their policies.

However, despite the circumstances, all was not lost, thanks to an *unpremeditated* effect of the market reserve policy. In reserving the lower end of the market for national producers the policy had the *inadvertent* effect of barring the entrance of foreign firms into the emerging micro market. By doing so a vital opportunity was provided for Brazilian firms wishing to enter the microcomputer market. They did not hesitate to seize upon this opportunity and on the basis of the new technology a whole new industry was spawned which was to become the fastest growing and most dynamic sector of the indigenous informatics industry and thus its very foundation.

National firms began almost immediately to produce clones of popular brand name microcomputers using standard off the shelf microprocessors. Easy access to microcomputer technology was made possible, as alluded to above, by virtue of the fact that the firms that pioneered the technology were merchant firms and therefore had no interest in restricting access to the technology.⁹⁸ Indeed, it was in their best interest to make the product as accessible as possible. Between 1982 and 1983 the number of Brazilian microcomputer producers registered a phenomenal growth rate of over 1000 percent, from 10 to 123. The growth of the micro producers was unrelenting and by 1985 there were more

than 300 firms in the computer industry in Brazil thriving primarily on the basis of the micro market.⁹⁹ As shall be discussed in more detail later, by allowing the unrestricted entry of these firms into the market CAPRE contributed to the fragmentation of the domestic market for informatics. This was to severely hamper the global competitiveness of the industry by limiting its ability to achieve scale economies.

Further signs of rapid development of the industry are reflected in export performance. According to a survey conducted by DIGIBRAS total exports of computers were only \$147,000 in 1982, yet by 1983 they had reached \$26 million. This phenomenal increase was partly due to the increase in the number of domestic firms engaged in export activity, from four in 1982 to ten in 1983. However, a substantial portion of the increase was due to the increase of the export activity of the multinationals, particularly IBM and Burroughs, as part of an arrangement with the government that would allow them to sell their medium sized systems in Brazil. This is discussed in more detail below.

In comparison, the mini market remained virtually stagnant. Aside from the original three firms who had entered the market no new firms entered the market. While the original firms continued to produce mini systems they also moved down the market to include microcomputers in their offerings.

This dramatic growth did not go unnoticed by the multinationals who launched their own challenges against the market reserve policy in the hopes of gaining some share of this lucrative market. Two of these challenges, one by IBM and one by Digital Corporation are of interest. IBM's challenge to the policy was what may be called a strategic move. Having been burned once by attempting to force its way through political pressure in to the mini market, IBM this time opted for a strategy of market undercutting based on product differentiation. It

did so by attempting to introduce its system 4331 medium sized computer. The 4331 was designed at the lowest spectrum of medium sized computers and thus its price was not far in excess of the Brazilian minisystems. On this basis IBM believed that by introducing the system into the Brazilian market it could lure customers from the mini market without violating the market reserve policy. Unfortunately, CAPRE was able to see through the smoke screen and prevented IBM from introducing the new system. However, it was not long before CAPRE's decision in this respect was overturned by the agency, Special Secretariat of Informatics (SEI), that replaced it in 1979. SEI decided to allow the introduction of the 4331 but restricted its sale to existing IBM customers and then only on the basis that for every unit sold in Brazil three would have to be exported.¹⁰⁰ Burroughs struck a similar deal and the result was a reversal of the import/export ratio situation of the multinationals existing in the early 1970s. IBM and Burroughs once the largest importers of computers and related equipment were now the largest exporters, although the gap between their imports and exports was not significant.

In contrast to IBM, Digital Corporation whose stake in the Brazilian market was much less than of IBM's, with only one sales and service branch, launched a direct challenge to the market reserve policy. Having obtained no satisfaction in its initial round of protests it turned to the U.S. government for assistance and the matter was brought up for discussion by the U.S. government at the 1977 multilateral Gatt negotiations. Despite pressure by the U.S. on Brazil to open up the lower end of the computer market to American suppliers the Brazilians did not relent. Neither did Data General which continued with the help of the U.S. government to fight the market reserve policy.

By 1984, however, after having exhausted virtually all other avenues,

and wishing to obtain a slice of the lucrative Brazilian market, Data General bowed to CAPRE's market reserve conditions and agreed to a technology transfer agreement with COBRA for its 32 bit super-miniprocessor technology in response to SEI's calls for proposals.

SEI and The Supermini

When IBM and Burroughs first attempted to introduce their midi systems into the Brazilian market they were prohibited from doing so by CAPRE on the basis that it would undermine the mini and micro computer. Moreover, CAPRE had plans of extending the market reserve to the midi segment of market. CAPRE's decision, however, was overturned by the Special Secretariat of Informatics(SEI) in 1980, one year after it had superseded CAPRE at the helm of informatics policy decision making. SEI, established by presidential decree in 1979, was attached to the National Security Council of the Presidency¹⁰¹ and was appointed to the position with the aim of centralizing informatics policy in Brazil. SEI became responsible for the entire informatics policy, including import licences but excluding the field of telecommunications which comes under the appropriate ministry which acts autonomously.

CAPRE's detronement marked a watershed in the development of the Brazilian informatics industry. The creation of SEI was the result of primarily two concerns, both emanating from the military. The first was the military's desire to ensure its conservative protectionist policies were carried on after the transition to democracy and civilian rule, and the second was to wrestle back control of COBRA from BNDE and thus through COBRA infuse a new defense element into the industry's base.¹⁰² Despite fears amongst the business community and former CAPRE officials, amongst other supporters of the market

reserve policy, that SEI would abandon CAPRE's policies and thus reverse the achievements made to date by the industry, SEI not only adopted CAPRE's policies but in many instances drew them even closer.¹⁰³ At the same time, however, SEI supplemented and in some instances supplanted those policies with the military's nationalist strategic considerations.

SEI's first president, Octavio Gennari Netto, opposed the exclusively Brazilian orientation of the mini and macro markets and argued instead, as did the multinationals, for a new strategy involving (1) the entry of multinationals into the protected markets in association with Brazilian companies and (2) redirecting government policy toward controlling, not eliminating, the participation of multinationals in Brazil.¹⁰⁴ It was under the directorship of Octavio that IBM and Burroughs were granted permission to market their midcomputer systems in Brazil. His decision resulted in strong cries from protectionists accusing him of betraying and abandoning the development of the domestic industry. Octavio appeared to be an outsider in daring to challenge the technological nationalism espoused by CAPRE and SEI.

Faced with strong opposition from nationalist forces, both from within and without the government, Octavio resigned in September of 1982. His successor was Colonel Joubert de Brazida, a veteran of the internal security forces and strong proponent of Brazil's nationalist protectionist doctrine.

Under the directorship of Brazida, SEI extended the market reserve policy to the next level of computers, the superminis. The primary motivation for doing so was the importance of the supermini to the military's national defence needs and objectives and the desire to rejuvenate the ailing mini industry. By extending the market reserve policy SEI won the support of the protectionists groups (indeed it itself became one of them). However, it was not long before it

agitated them again by adopting a strategy of buying foreign technology for the superminis, as exemplified in the case of Digital Corporation and COBRA mentioned above. The decision to seek foreign technology went explicitly against CAPRE's strategy of relying on the development of indigenous technology.

The minicomputer industry had proven incapable of making the transition from the 16 bit mini technology to the 32 bit supermini on its own. The survival of the industry required the infusion of foreign technology. The protectionist were eventually appeased by SEI's requirement that only 100 percent Brazilian firms be allowed to produce the supermini with the foreign technology to be transferred within five years. Moreover, it placed increasing pressure on the multinationals to increase their export activity.

In 1984 a new round of competitions was held for local firms wishing to make bids to license the technology and manufacture the supermini. The selection criteria were the same as for the 1977 competition. As in the last competition three wholly owned Brazilian firms won the competition. Two of the newcomers were, as in the case of the original Brazilian mini producers, affiliated with large financial institutions.¹⁰⁵ The entry of these new firms into the minicomputer market was to further fragment the market, begun by the unrestricted entry of firms into the microcomputer market, thereby further hampering the industry's ability to achieve scale economies and becoming a globally viable concern. I will return to this topic shortly.

The largest informatics firms in the country were now all affiliated with the country's leading financial institutions, who also happened to be the former's principal customers by far. Two factors have been primarily responsible for the heavy orientation of these firms, and to a lesser degree the Brazilian computer

industry in general, to the development of technology regarding products for bank automation. The first is that given the large stake that the banks have in the industry they become, by association, a natural market for the industry to exploit. From the banks' point of view not only are they acquiring the products they require but they are ensuring a return on their original investment. The second factor is the spiralling inflation which has and continues to afflict the country. According to an executive of the Itaú bank "the banks had to automate their services, providing on-line service to the client because high inflation forced the customer to demand more speed and agility in their financial operations."¹⁰⁶ Moreover, due to the inflation problem the banks themselves required much greater speed in order to conduct their domestic and international money transactions.

All three of the new super-mini producers were successful in their bids to source technology from foreign suppliers. However, SEI's decision to allow the use of foreign technology should by no means be construed as a softening of the prevailing anti-dependency strategy. On September 20, 1984 SEI introduced a national informatics policy which was subsequently passed by congress in October and came into effect as the new national informatics law in November. The law was highly protectionist in nature and served as the military's guarantee that its concerns and policies would remain intact after the scheduled transition to civilian rule in early 1985.

The new law not only maintained much of CAPRE's directives but placed them on firmer ground. The market reserve policy concerning the mini and macro segments was extended for a period of eight years and a system of control of imports of goods and services relating to computer technology was instituted for the same period of time.

One of the law's primary objectives was to increase the degree of autonomy in regard to informatics technology. To this end technology transfer agreements were to be limited to a duration of no more than five years, thus carrying on CAPRE's conservative stance in regard to technology transfer. Moreover it emphasized the urgent need to strengthen Brazil's capabilities in the area of components (semiconductors). This was of utmost importance to Brazil's anti-dependency strategy given Brazil's critically low capabilities in this area and the emergence of VLSI technology signalling a shift to significantly higher systems integration as discussed in part one.

SEI, Semiconductors and Dependency

The rapid growth of mini and macro producers throughout the late 1970s and early 1980s was not accompanied by similar growth in the components sector. Thus, during the years of rapid growth, Brazil's dependence on imports shifted from final products to components.¹⁰⁷ This dependence became particularly acute with the advent and diffusion of VLSI technology. As discussed in part one, the advent of VLSI technology gave rise to a trend towards convergence between the upstream, midstream and downstream sectors of the microelectronics industry due to much greater systems integration in the component itself as opposed to the final product. This had the dual effect of shifting value added away from final product manufacturers to component manufactures and encouraging both backward and forward integration resulting in a shift in competitive advantage to vertically integrated firms. Combined with the associated escalating costs of R&D and shortening product life cycles necessitating the development of scale economies, this resulted in major new technological and size barriers to entry which had severe implications for the

Brazilian informatics industry.

The national industry, comprised primarily of small firms dedicated to the manufacture of final products and lacking the financial resources to undertake required R&D were placed in a highly uncompetitive and dependent situation vis a vis the multinationals. The latter's size, resources and global orientation enables them to introduce a constant flow of new products at low prices based on scale production and selling in huge volumes on the world market. Under these circumstances it was extremely difficult for small local Brazilian manufacturers to achieve the industrial scale required to maintain a globally competitive informatics industry. To understand these difficulties it is necessary to dwell deeper and examine the structure of the semiconductor industry.

In 1984 aggregate Brazilian demand for semiconductors amounted to \$179.6 million dollars. Of this amount \$84 million was attributed to the IC market of which \$51.4 million was accounted for by digital ICs. The sectoral distribution of demand for digital ICs is reflected in Table 5.1

Table 5.1 Distribution Of Brazilian Demand For Digital ICs

Sector	Demand (in millions of \$ U.S.)
Computer ^a	26
Telecommunications	12.2
Consumer Electronics	12.4

^aOf this amount \$17 million was accounted for by IBM and Burroughs.

Source: S. Wajnberg, 14.

In 1984 there were eighteen semiconductor firms operating in Brazil. Fourteen of these firms were solely engaged in the assembly and test stages of the production process, requiring the least amount of skill and capital out of all the stages. Additionally most of these firms were multinationals.

Only four were engaged in the execution of the complete production process. Of these only one firm, SID, was Brazilian.¹⁰⁸ However, two other Brazilian firms, Itautec and Telebras (the Digibras of the telecommunications industry) and one state owned research institution, the Microelectronics Institute, were in the process of establishing or planning to establish complete production facilities from design to testing. This, however, may be a highly risky and inefficient move on their part given the relatively small size of the Brazilian market for semiconductors.¹⁰⁹ As one author notes "Taking into account the extent of the Brazilian and Latin American industries, one single photomasks generation center would meet the needs of local industry at LSI (large scale integration) ICs."¹¹⁰

SID's purchase of Philco and the plans by the other nationals for the establishment of complete semiconductor production facilities were largely made possible by SEI's 1983 decision to apply its computer policy framework to the semiconductor market, thus reserving the IC sector of this market for national firms. The rationale behind SEI's decision was to lower and eventually eradicate Brazil's growing dependence on components, particularly digital devices upon which all modern computers are based.

At the time of the policy's initiation a few Brazilian enterprises, namely SID and the other three nationals mentioned above, possessed semiconductor design capabilities. However, none of them, including SID, the most advanced of all the semiconductor producers, possessed the required design capabilities for

VLSI devices. For such devices they had to rely entirely on imports as they had to with advanced processors such as the 32 bit architectures.

The ability to undertake the complete production process for ICs, for both memory and processor devices, requires the prior internalization of extensive technological and some basic scientific knowledge in such areas as solid state physics, electrical engineering, chemistry, and material science, etc. At the time of SEI's implementation of its market reserve policy the internalization of these areas of knowledge in Brazil was incipient. As noted earlier, virtually all the multinational semiconductor companies only carried out the final stages of the IC production process in Brazil and accordingly, as in the case of computers, carried out next to nothing in regard to R&D.

Private R&D spending by national firms was also inadequate, primarily due to two factors. First, given the traditionally low risk, low capital, quick return attitude of Brazilian firms, they have tended to shy away from the highly capital intensive, high risk, long run return nature of R&D required by this industry. Second, and of greater significance, has been the fragmented nature and limited economic size of the Brazilian informatics market which has limited the ability of national firms to assembly.

As for state investments there are no specific figures available. However, Wajnberg has noted in his study of the semiconductor sector in Brazil that state investment in human resources, capital equipment and research are inadequate for the development of a competitive and efficient industry.¹¹¹

In light of this, SEI's decision to reserve the market at such an early stage in the development of design and production capabilities by Brazilian firms seems highly questionable. This is particularly so given the negative effects which CAPRE's market reserve policy had, with respect to the policy's timing

and manner of implementation, in the minicomputer sector.

In the foregoing pages the negative implications of CAPRE and SEI's decisions have been alluded to on several occasions. In what follows I propose to bring these to the fore by examining the effects they had on the industry's structure and competitive capacity and substantiating the argument with empirical evidence. The intent of this is to assess the efficacy and viability of the informatics policy within the context of the industry's global competitiveness.

Informatics Policy and Industry: An Assessment

In the early 1970s there was really no informatics industry in Brazil. Virtually all of Brazil's informatics needs from computers to components were met by way of imports. In short, in terms of its informatics needs, the country was in a situation of extreme dependency. By the early 1980s, however, the situation had improved dramatically. Through the use of a highly protectionist policy of market reserve, strict import controls and government procurement the country had made enviable progress in the establishment of a domestic informatics industry, as compared to virtually every other developing country. By 1985 there were close to three hundred domestic computer firms, serving a rapidly growing market, estimated at a rate of 25 percent per annum in 1985, of which they possessed a substantial share.¹¹² In the process, these firms have developed some technological capabilities in the design and manufacture of computers and semiconductors and their success in this respect has given rise to the training of a substantial number of skilled personnel.

For an industry, *de facto*, established only in 1977 Brazil's

accomplishments are highly commendable. At the same time, however, within a global context the industry appears to be uncompetitive and inefficient in most sectors in terms of price, quality and performance in comparison with similar products on the world market. National firms have been unable to sustain an adequate level of productive efficiency and have failed to go beyond incremental innovations within well known and relatively open technologies. Overall the industry is lagging behind, in certain crucial areas, the global technological and competitive frontier.

These deficiencies are primarily the result of the misguided and imprudent measures of the informatics policy which failed to take account of global industry conditions and subsequently adequately assess domestic market conditions and technological capabilities. My presupposition is that the root cause of these shortcomings has been the technological nationalism of the policy formulators which blinded them to these considerations. Consequently, this blinkered outlook has resulted in the development of an industry that is at odds with global industry characteristics and standards in terms of vertical integration, R&D resources, technology acquisition, and global strategy and therefore uncompetitive. In what follows I will attempt to substantiate this hypothesis. Specifically, I propose to show how the informatics policy's shortcomings resulted in contracting the size and fragmenting the structure of the market thereby limiting the ability of the industry to achieve the scale economies necessary to ensure its long term sustenance.

Market Size, Industry Structure and Efficiency

As noted earlier, the Brazilian informatics market is of considerable size, ranking as the twelfth largest in the world. In 1985 the industry's gross revenues

amounted to approximately \$2.3 billion. Slightly more than half of this amount, \$1.16 billion, was accounted for by national firms and concentrated in the lower end of the computer market as represented by micro and mini computers. The remaining share of the revenues, \$1.4 billion, was accounted for by the multinationals and concentrated in the upper segment of the market as represented by large and very large computer systems.¹¹³ Despite the multinationals' demise in the lower end segment of the market, due to the market reserve policy, their position in the high end of the market, in terms of value, remains virtually unchanged.

The size of the market is complemented by equally impressive growth rates, averaging 25-20 percent per annum in the late 1970s levelling off to approximately 18 percent in the early 1980s.¹¹⁴

Despite the substantial size of the informatics market and its healthy growth prospects, making it the largest and fastest growing in all of Latin America, it is still relatively small when compared to the markets of other nations. In 1984 the Brazilian informatics market represented less than 20 percent of the German market, 10 percent of the Japanese market and a mere 3 percent of the American market.¹¹⁵

The small size of the informatics market is not merely a product of Brazil's lower GDP in comparison to that of the countries mentioned above. It is partly a product of the market reserve and import control policies which had a decisive impact on the rate of diffusion of computing among Brazilian firms.

The market size limiting effects of the informatics policy are the result of the timing and the manner in which the market reserve and import control components of the policy were implemented.¹¹⁶ The combination of these two factors had a decisive impact on the rate of diffusion, and consequently the

growth rate, of computers in Brazil. Between 1975 and 1976 the market for all computers grew at a rate of 35 percent. Partly as a result of CAPRE's import controls on medium and mini computer systems the growth rate dropped dramatically in 1977 to 16.2 percent and even further in 1978 to 11.4 percent. This is clearly an indication of the premature imposition of CAPRE's controls, which were implemented prior to the availability of a sufficient range of nationally produced computers to meet demand, thus reducing supply.¹¹⁷ The effect of the market reserve policy on the growth of the minicomputer sector was even more dramatic. Here the growth rate plunged from a high of 67 percent in 1974 to a low of 12.8 percent in 1978 before making modest gains of 1.4 percent and 6.6 percent in 1979 and 1980 respectively. The sharpest falls coincided with CAPRE's implementation of market reserve in 1977 (Table 5.2).

While the supply of minicomputers decreased the demand for minicomputers increased. Demand for these systems continued to rise due to the increasing need of the banking industry for automated financial systems, for reasons discussed earlier, and the need by as yet un-computerized firms to automate in order to maintain competitiveness against already automated firms. Under this scenario, demand outpacing supply, the ultimate result of CAPRE's policy was to shift demand away from the lower end of the computer market, since supply was constrained, toward large systems which were readily available. Under these conditions the demand for large systems grew by 36 percent in 1978 (Table 5.2). CAPRE also directly encouraged the use of large systems by systematically advising those who sought to purchase very large systems to instead consider purchasing large systems.¹¹⁸

Table 5.2 Growth Rate Of The Brazilian Minicomputer Market (Percent)

Year	Very large	Large	Medium	Small	Mini	Total
1974	-	-	-	-	67.0	-
1975	-	-	-	-	4.0	-
1976	18.0	20.7	1.8	24.4	46.2	35.3
1977	20.8	23.2	4.4	1.0	23.9	16.2
1978	6.8	36.0	4.8	6.3	12.8	11.4
1979	4.3	36.1	1.8	8.4	14.2	12.7
1980	26.8	9.7	2.9	7.0	20.8	18.1

Source: Adapted from: Raul Luciano Katz, 104-105.

In sum, motivated by political factors discussed earlier, CAPRE's policies and later those of SEI's had the effect of contracting the computer market given the inability of Brazilian firms to meet the markets needs. It was not until 1980 that Brazilian firms began to satisfy the market's needs. However, even then they lacked the capability to meet all the demand and so both demand and supply remained constrained for some time longer.¹¹⁹ While CAPRE and SEI progressively raised the ceiling on imports in the following years this was more a reflection of the rapidly rising inflation rate rather than a reflection of a more liberal or 'pragmatic' stance towards imports.

The detrimental effects which the market reserve and import control aspects of the policy had in terms of limiting technological diffusion and thus the size of the market for computers were *not inherent* to these measures. As stated in Chapter Three, such measures are vital in enabling infant industries to develop competitive capacities in such areas as scale economies. Rather, the detrimental effects which these measures have are a product of the timing and the manner in which they were implemented. Given the capabilities of Brazilian firms at the time, import controls were too excessive as was the market reserve policy in its

instantaneous blanket application. Had these two measures been implemented in a gradual fashion in accordance with the capabilities of Brazilian firms their detrimental effects could have been avoided for the most part.

Despite the negative consequences resulting from the manner in which the market reserve policy was implemented in regard to the computer sector SEI did not heed experience and in 1984 extended the market reserve policy, applying it in virtually the same manner, to the semiconductor sector. While no data is available on the effects of the policy in this sector it may be postulated on the basis of the minicomputer experience and the inadequate level of technological capability and R&D resources possessed by Brazilian firms in this sector that the policy's negative effects will be as severe, if not more so, in this sector than in the computer sector. This is so because the technology in this sector is much more complex and R&D and capital intensive than in the computer sector. Moreover, given the increasing systems orientation of technology in the semiconductor sector the consequences of the policy will no doubt have ripple effects extending throughout the informatics industry thus multiplying the negative effects that will likely arise.

The market reserve and import controls had a much larger impact than only restricting the rate of diffusion and the size of the market. Issues such as market fragmentation and technological dependence must also be included in a larger assessment of the Brazilian informatics policy. It is to these that I now turn.

Earlier it was noted how the advent of the microprocessor and the market reserve policy set the stage for the rapid and unrestricted entry of national firms into the informatics market. The unrestricted entry of these firms into a market of limited economic size has undermined the ability of the

industry as a whole to take advantage of scale economies, so crucial to the industry's competitiveness. This is confirmed by Frischtak's examination of the level of concentration (based on the sales of the ten largest computer firms) and product price differentials compared to similar products available on the international market. In his study Frischtak found that between 1979 and 1983 in the mini and micro computer segments of the computer sector the sales concentration of the five and ten largest firms had decreased by a substantial amount; "when we consider gross sales, the five and ten largest firms decrease their respective market share from 88.8 percent to 46.4 percent and from 98.0 percent to 65.8 percent in the four year period 1979/83..."¹²⁰ The reason Frischtak cites for the decrease in sales concentration ratios is the unrestricted entry of new microcomputer firms into the industry, which have tended to undercut the sales of the minicomputer firms, and the licensing of new firms to manufacture minicomputers. Unrestricted entry has thus nullified the prepotency of market reserve and import controls in enabling domestic firms to exploit scale economies.

Rather than build on a smaller number of well established firms Brazil has opted for a strategy of production based on numerous small firms, as means to avoid the high degree of concentration characterizing the high end of the computer industry dominated by multinationals and to encourage specialization. As a consequence of the strategy, given the limited economic size of the market, major obstacles have developed in the way of achieving economies of scale, in both production and R&D, thus hindering efficient production comparable to international standards.¹²¹ As Frischtak notes "the manufacture of computers and peripherals is mostly characterized by its batch nature, which is incompatible with levels of productive efficiency necessary to

make the industry internationally competitive."¹²² Additionally, given the limited economic size of the domestic market the industry's inward orientation has resulted in a zero sum situation in which one firm's gain of market share is achieved at the expense of another firm's share.¹²³

As a consequence of the sector's inefficient production levels the price of Brazilian computer products in terms of cost/performance ratios is uncompetitive by international standards. While the price of CPUs is competitive by international standards, averaging five to six percent higher than U.S. price, the price of complete mature systems employing open architectures¹²⁴ are much higher in comparison to U.S. prices, being on average 18 to 38 percent higher. In the case of new systems employing closed architectures the situation is even worse with prices approximately 38 to 49 percent higher than U.S. prices for similar products.¹²⁵ The reason for the much higher price performance differentials in closed architecture system lies in the lack of scale economies in the semiconductor sector.¹²⁶

The relatively limited economic size of the market for informatics products in Brazil and the fact that this sector is the largest consumer of semiconductor devices, particularly ICs, has inevitably resulted in retarding the development of sufficient scale economies necessary to achieve international competitiveness, in terms of price/performance ratio, in the semiconductor sector.¹²⁷

The government has attempted to overcome this situation by reserving the domestic market for semiconductors to local producers. This, however, as alluded to in Chapter Three, has had the effect of driving up the costs of inputs to downstream computer manufacturers who rely on protection for their products and low duties for their inputs. Consequently, the price of their

products has risen above international prices for similar products.

The exception to the uncompetitive price/performance ratio of Brazilian computer products is in automated bank products. Here, thanks to the criteria and outcome of the minicomputer competitions, the price/performance ratio of Brazilian products is quite competitive. As shown earlier, in the first round of minicomputer competitions one of the central selection criteria was that minicomputer firms concentrate on the development of the central processing unit, leaving to other firms the manufacture of peripherals and all other informatics products.¹²⁸ The primary objective of this criteria was to encourage specialization which was seen as a means to consolidate R&D efforts and, moreover, bring about increasing returns to scale.¹²⁹ Specialization was also inadvertently encouraged by CAPRE and SEI by the choices that they made in their licensing of minicomputer producers. As revealed earlier, in both minicomputer competitions virtually all the successful firms were closely affiliated to large financial institutions. As a result, these firms, which are the largest national producers of informatics equipment in Brazil, are highly specialized in the provision of equipment geared almost exclusively to the needs of the financial sector, such as CPUs for financial automation, banking terminals, automatic teller machines and the like.

The high degree of specialization has paid off for the industry in two respects. First, it has enabled them to take advantage of a limited degree of scale economies in production, thus making their products relatively price competitive by international standards. Second, it has enabled them to achieve a relatively high level of technological sophistication in the products concerned. The combination of a competitive price and technological sophistication has made automated banking products one of the very few areas in which these

firms have met with export success. The main export market, by far, for these products has been South America, especially Argentina. However, as shall be discussed later, the total value of these exports remains extremely low and the potential for future growth remains highly precarious.

At the same time, the high degree of specialization by these firms has had negative consequences which tend to far outweigh the benefits. The most serious of these is the lack of economies of scope resulting from excessive specialization which has reduced the possibilities for cost savings resulting from the simultaneous production of several different products in a single enterprise.

Excessive specialization has also resulted in a situation of dependence. By gearing much of their production to supplying the needs of the financial sector the minicomputer firms have become highly dependent on this market for sustenance and thus highly vulnerable to fluctuations in demand. Moreover, they have not been able to reap the benefits of diversification relating to R&D.¹³⁰

Research and Development:

The lack of a sufficiently large market (relatively speaking), inadequate production scales and an insufficient degree of vertical integration have combined to undermine the ability of Brazilian informatics firms to muster the immense financial resources required to conduct R&D in the scale and depth required by the rapid and increasingly complex pace of technological change occurring globally in order to maintain competitiveness. While a number of Brazilian firms invest a substantial percentage of their sales in R&D activities this amounts to little in absolute terms, given their small size.¹³¹ The existence of numerous small firms resulting in a fragmented market does not allow firms to go it alone in undertaking the large scale R&D efforts required, particularly in

light of the high risks involved due to shortening product life cycles, as discussed in Chapter Two, which has necessitated large scale production levels in order to recuperate costs which national firms are incapable of achieving. To exploit scale economies in R&D and sustain the risks involved in a fragmented market of limited economic size would require firms to engage in cooperative R&D ventures. The highly competitive nature of the market, however, has mitigated against such ventures and consequently available resources have rarely been pooled.

Thus it is that a substantial proportion of R&D activity in Brazil is undertaken by the state, not only in the informatics industry but in most industries, particularly strategic industries considered vital to national security and defense applications.¹³² Virtually all R&D funding is channelled through the National Fund for Scientific and Technological Development (FNDCT). Established in 1979, the FNDCT is the principal instrument for the implementation of S&T policy. Since 1974 the FNDCT has been under the authority of the National Research Council (CNPq) which is responsible for overall science and technology planning. Overall, the level of FNDCT resources increased in real terms from 1969 to 1975, then fell in 1976 and 1977. They managed to rebound in 1978 only to fall dramatically in 1979, victim to government expenditure cuts throughout the economy. FNDCT's primary objective has been to develop the research infrastructure in Brazil, particularly human resources. Between 1969 and 1979 the largest amount of resources, fully fifty percent, went to "Scientific Development and Human Resources for Research" while the amount of new resources devoted to the development aspect of R&D has amounted to only sixteen percent of total resources over the same period.¹³³

The lack of R&D efforts by domestic firms combined with the low percentage of funds allocated by the FNDCT to the development aspect of R&D would indicate the existence of a weak feed back loop between learning by using and the development aspect of R&D.¹³⁴ As discussed in Chapter Three, in the development aspect of R&D, learning is oriented toward the commercial dimensions of the innovation process; that is towards discovering the nature and combination of product characteristics desired by the market and incorporating these in a final product in ways that take into account scientific and engineering knowledge. This points to the existence of a feedback loop between learning by using and the development aspect of R&D. Therefore, it follows that if one pole in the loop is weak the amount of feedback transmitted through the loop will be limited. This is borne out by the innovative capabilities of Brazilian informatics firms.

Most national informatics firms have been able to make a substantial number of incremental innovations, either through a process of reverse engineering or through the licensing, transfer and effective absorption of foreign technology. With respect to reverse engineering, virtually all successful attempts have been based on open architecture systems. Similar attempts at reverse engineering in regard to closed architecture systems based on VLSI and ELSI technology will prove to be much more difficult. The highly complex nature of this technology will require much greater R&D outlays and thresholds of technological capability than national firms are capable of due to the structural constraints imposed by the size of the market.

In regard to licensing agreements there were two major reasons national firms entered into them: one, to avoid the high costs and time involved in local development of the technology and, two, the lack of technical ability given the

complexity of the technology particularly in the area of ICs. Once having licensed the required technology virtually all national firms have proven capable of abiding by CAPRE's and SEI's directives of relying on their own capabilities for the up-grading and further development of the licensed technology. Minicomputer producers have generally done so by shifting to microcomputer technology which, as noted earlier, has been available on a merchandise, off the shelf basis.

However, despite the success of national firms in making improvements within a given generation of products they have not been nearly as successful in making innovations resulting in the development of a new generation of products. This is exemplified by the case of minicomputers where, as revealed earlier, despite the pioneering firms success in adapting and improving upon the technology they failed to make the transition to the new 32-bit technology employed by the supermini and eventually had little choice but to resort to licensing the technology.¹³⁵ While the number of technology transfer licensing agreements has diminished, in 1981 of the eighteen largest national informatics producers, eleven still had licensing agreements which "were either classified as important or very important and no radical shifts in sourcing technology have been received (1984) since then."¹³⁶ The existence of licensing agreements should not be interpreted as a reflection of a liberal stance towards technology transfer on the part of SEI and CAPRE. The licensing agreements were seen as a measure of last resort and agreed to on the basis of what may termed desperation on the part of the state. The industry had begun to stagnate, incapable of making the transition to the next generation technology, and without the licensing of new technology it could very well have been doomed to decline.

In sum, despite the technological efforts undertaken by national producers, they remain unable in some crucial areas to move beyond adaptive R&D efforts and improvements in the engineering of systems. While Brazilian producers have managed to develop in depth capabilities in some areas they have been much less successful in advancing to higher levels of technology and are therefore uncompetitive by international standards.

Overcoming the Obstacles

In view of the limited economic size of the domestic market which has severely constrained the competitive capacity of Brazilian firms from the standpoint of cost and technological sophistication, the national informatics industry should be encouraged to expand its exports as a way to overcome the domestic scale limitations and move towards more sophisticated and contestable market structures.

Beginning in the early 1980s a few of the largest informatics firms, specializing in financial automation systems, began turning to exports as means to compensate for sluggish demand in the domestic market for their financial automation systems. By 1985, however, the combined exports of Brazilian informatics firms amounted to a mere \$10 million.¹³⁷ Virtually all of this was comprised of systems for bank automation destined for Argentina with a small proportion going to countries in the Middle East. The low export sales of Brazilian firms and the fact that much of it was destined for developing country markets less sophisticated than their own, indicates that national firms could not have garnered either the static or dynamic efficiencies associated with demand.

And therefore they have failed to overcome home based disadvantages or supplement home based advantages through exports.

To gain the static efficiencies associated with demand, Brazilian firms will have to greatly intensify their export efforts. This may be done without regard to the level of sophistication of the export markets since the level of sophistication is at most a minor factor in static efficiencies. As explained in Chapter Three, static efficiencies are quantitative in nature and are associated with market size and economies of scale. Dynamic efficiencies, on the other hand, are qualitative in nature and are associated with the markets level of sophistication. However, static efficiencies should not be seen as an end in themselves but as a means to achieve the scale economies, and thus the cost advantages, necessary for gaining a foothold in more competitive and sophisticated markets. By this is meant the markets of the OECD countries, wherein lies the opportunity for gaining the dynamic efficiencies of demand so crucial to innovative capacity and competitiveness in high technology industries.

Among the options available for gaining a foothold in these markets and expanding exports, serious consideration should be given to original equipment manufacture (OEM),¹³⁸ joint ventures and co-production arrangements. Such arrangements have been used extensively by the East Asian NICs, particularly Korea as shall be shown shortly, and proven highly effective in their drive for export expansion. The need for greater economies of scale in manufacturing in the microelectronics industry, which often requires specialization in specific product lines, in addition to the need for developing strong regional sales and service networks by multinational microelectronics firms has been a major cause of growth for such arrangements.¹³⁹ While some of the larger Brazilian informatics firms have partaken of the advantages of such arrangements the total

value of these agreements remains relatively small.¹⁴⁰ In addition to the export expansion dividend, such arrangements may have substantial payoff potential in terms of either formal or informal technology transfer. Additionally, in so far as such arrangements result in the expansion of exports, and consequently the scale of production, they will increase the potential of Brazilian firms for learning by doing and enable them to travel the learning curve faster than before. This in turn will enable Brazilian firms to master new technologies more quickly and thus increase their capacity for delivering new products to the market more quickly.

Protectionist Policies and Liberalization

Going global, however, will require some fundamental changes in the underlying thrust of the informatics policy and its objectives. This must include, amongst other measures, the liberalization and focusing of protectionist policies governing the industry and a more liberal and progressive stance in regard to technology transfer. The aim of such measures ought to be the restructuring and upgrading of the domestic market structure in order to overcome the limitations on the industry as outlined above.

Market Reserve: Earlier on I alluded to the highly competitive structure of the lower end of the Brazilian computer industry due to the existence of numerous relatively small firms. The nature of this competition, however, is based almost entirely on the rivalry between national firms for market share. Thanks to the market reserve and import control policies, national firms have been cradled in a hermetically sealed environment free of the exigencies of foreign competition based on more sophisticated and price competitive technology. This has, no doubt, to some extent been a cause of complacency on

the part of Brazilian firms in regard to upgrading technologically and especially in regard to aggressively seeking out export markets. Since the only competition which Brazilian firms face is domestic (ie: national) competition with more or less equal technological capabilities they have not had the requisite incentive to upgrade as rapidly as they might have if faced with more sophisticated foreign competition. Moreover, the provision of a guaranteed domestic market free of foreign rivalry with no *firm* time limit for the removal of this form of protection has provided little incentive to Brazilian firms to seek out and penetrate foreign markets.

This is by no means a call for the eradication of the market reserve and import controls. To the contrary, such policies are an absolute for the development of high technology industries in developing countries given their technological and economic lag in relation to the industrialized countries. However, in order for such protectionist policies, from the entry of foreign producers, technology and equipment, to be effective it is necessary that they be focussed and time-bound, both qualities that are wanting in Brazil's informatics policy. The need of a focussed and time bound approach stems from the need for efficiency in implementation. This would help to guard against complacency and, thus, alert national firms to the need for rapid and continuous upgrading of capabilities and expansion of operations.

Additionally, it is imperative that the timing and manner of implementation of such policies be carried out with great consideration to domestic capabilities. This would require that they be implemented in a gradual fashion in accordance with the ability of domestic firms to meet demand. As we saw earlier, however, CAPRE and SEI's implementation of market reserve and import controls in regard to the minicomputer and semiconductor sectors were

carried out in an instantaneous and blanket fashion with little consideration to the technological capacity of domestic firms. Their preoccupation with technological nationalism blinded them to the need for such considerations. In the minicomputer sector this blinkered outlook had the effect, as was shown, of contracting the size of the market and slowing the rate of diffusion.

Finally, it is necessary that the implementation of such protectionist policies be gauged against specific policy targets defined in reference to international price-performance standards with the aim of bringing the industry up to international standards. In Brazil, however, such standards have been given inadequate attention due to the inward orientation of the informatics policy. Moreover, policy targets have tended to be defined in rather broad terms; concerned more with such capacious final objectives as national control and self-sufficiency rather than with the specific means, such as R&D and production targets, required for the efficient attainment of its set objectives. In essence the informatics policy's overriding concern with its nationalistic agenda has been achieved at the expense of the efficiency of the means employed to achieve the latter. This is reflected in the shortcomings of R&D deployment by Brazilian firms and CAPRE and SEI's restrictive and narrow disposition towards technology transfer.

R&D and Technology Acquisition

In order to overcome the financial and human resource constraint faced by the industry in conducting R&D it is imperative that measures be taken to focus and consolidate R&D activities. First, cooperative arrangements and closer links between firms, research institutes and universities need to be established. This will not only result in a more efficient allocation and use of R&D resources

but will also be conducive to the development of a feed back loop between the market and the development aspect of R&D which, as noted in Chapter Three, is essential to the development of innovative capacities based on learning by using.

Second, a greater degree of concentration in the industry's structure should be encouraged; through such means as encouraging smaller firms to merge with larger firms and/or restricting the entrance of new firms into the industry. This would bring about an amalgamation of the fragmented market structure and thus enable firms within the industry to consolidate R&D resources and take advantage of greater scale economies in production and R&D.

For highly complex and idiosyncratic technologies where the costs and time involved for local research and development are economically inefficient the acquisition of foreign technology should be encouraged on a selective basis. While technology transfer has played a crucial role in the development of the Brazilian informatics industry, most notably in the minicomputer sector, it has in general been cast in an ominous light due to the informatics policy's underlying emphasis on nationalism and self sufficiency. Imports of embodied technology in the form of products and equipment have been severely restricted by the import control policy and licensing agreements have been resorted to primarily as a last means and generally regarded as a once and for all deal and highly restricted. Additionally, the market reserve policy has worked against joint venture agreements by barring foreign firms from the market.

As discussed in Chapter Three, however, in an industry such as microelectronics the rapid pace and complex nature of technological change combined with the relatively limited resources and capabilities of developing countries, maintaining competitiveness requires that technology transfer be

regarded in a progressive light; one in which technology transfer and successful assimilation and absorption are carried out on a selective yet continuous basis. In this way technology transfer can be used as a strategic instrument to complement local technological activities and capabilities.

As discussed earlier, globalization, through the location and coordination of activities on a global scale, can play a key role in the acquisition of foreign technology. This form of technology sourcing has the advantage of providing firms with early and first hand knowledge of the direction of technological change. Moreover, as stated in Chapter Three , it may lead to greater economies of scale and learning through exports and by allocating different tasks to subsidiaries, thus allowing for specialization.

Conclusion: Problems and Prospects for the Future

The foregoing has attempted to ascertain the vitality of the Brazilian informatics industry within the context of technological change occurring globally and the competitive national and corporate strategies required in order to manage and reap the benefits of this change. The two most pressing issues that will face the industry in the years to come will center around its ability to effectively increase its level of productive efficiency and decrease and maintain the technological gap at a manageable and internationally competitive level. As noted throughout this study the lack of production scales, a narrow R&D base and an insufficiently competitive environment have been the major cause of inefficiency, high price-performance ratios and the general inability to move beyond incremental improvements in established foreign technologies. The

highly inward orientation of the industry and the existence of a relatively large number of firms in relation to the limited size of the market are incompatible with large production and R&D scales. In order to achieve a more competitive environment and large scales in production, increasing returns to scale and R&D compatible with international standards, as dictated by the pace and nature of technological change, a change in the policy framework governing the industry and the way the industry is structured are needed.

The central question for policy makers, therefore, will be the formulation of a coherent strategy that will enhance the competitiveness of the national industry; enabling greater cost efficiency and technologically progressive behavior. This will essentially require the re-structuring of the industry more along Schumpeterian lines within the context of a globally oriented strategy, as discussed in Chapters Two and Three, and a more progressive and dynamic stance towards technology transfer.

The 1990s: New Challenges

In 1990 the saga of the Brazilian informatics industry took a dramatic turn. Acting under the pressure of U.S. trade sanctions against a wide variety of Brazilian products the Brazilian government rescinded its market reserve policy pertaining to the informatics industry.

While the U.S. government had long objected to Brazil's market reserve policy, as demonstrated by the case of Digital Corporation discussed earlier, the imposition of sanctions was prompted by a Brazilian government decision to deny to Microsoft Corporation (U.S.A.) permission to market its MS-DOS software system. The U.S. had previously threatened Brazil with sanctions but this time, to the surprise and dismay of the Brazilian government, it actually

moved from words to action.¹⁴¹

The decision by the Brazilian government was prompted by two factors. First, Brazilian exporters, in industries other than microelectronics, alarmed at the prospect of losing lucrative markets abroad forcefully urged the government to deal with U.S. objections. Second, given Brazil's acute economic crisis, sparked by a suspension of most foreign debt payments, it was in no shape to handle a trade war with its principal economic partner, one that in 1986 bought US\$6.2 billion of Brazilian goods.¹⁴²

The abrogation of the market reserve policy will no doubt have far reaching consequences for the informatics industry. On the plus side the introduction of foreign products into the market will force domestic firms to become much more competitive in terms of upgrading innovative capabilities and expanding and diversifying their demand basis. The government, aware of the new challenges posed by foreign competition, has adopted a more progressive stance in regard to technology transfer. Domestic firms are now encouraged to form joint-venture and licensing agreements with foreign firms in a bid to upgrade their technological capabilities so that they may compete with foreign products.

The negative consequences resulting from the instantaneous removal of the market reserve policy, however, loom much larger. The annulment of the market reserve policy was not accompanied by any measures to restructure the domestic industry with the aim of amalgamating production capabilities and R&D resources, thus overcoming the structural constraints discussed above. Thus, the fragmented structure of the industry will place it in a clear disadvantage when faced with the vast R&D resources and production capabilities possessed by foreign firms.

Moreover, the instantaneous removal of market reserve has undermined the trump card of domestic firms in bargaining for foreign technology, namely, access to the domestic market. This could have been avoided if the policy's removal was conducted in a gradual fashion on the condition that foreign firms would be allowed access to restricted areas if they agreed to transfer technology to domestic firms. As it stands, the policy's instantaneous removal is likely to nullify much of the benefits of the government's new progressive stance in regard to technology transfer.

In sum, the Brazilian microelectronics industry appears to be at the most critical juncture of its history. In the absence of any substantive structural reforms to the industry the government in its haste to satisfy U.S. demands may have thrown the baby out with the bath water. These reforms, as already noted, would have to include the removal of obstacles to mergers and the encouragement of the industry's amalgamation. This would go a long way to solve the problem of market fragmentation and enable the aggregation of resources. Thus the remaining firms would be in a better position to take advantage of scale economies in R&D and production. Moreover, to increase the opportunities for scale economies the state should provide incentives, in the form of subsidies and/or lower exchange rates, to encourage firms to more aggressively exploit export opportunities.

However, the instantaneous removal of the market reserve policy has made the restructuring of the domestic industry extremely difficult. The industry must be given short term, firmly time bound protection that will provide it with the breathing space to restructure. Short of needed reforms, especially in light of the new challenges, the industry's survival more than ever before hangs in the balance.

The Development of the Korean Microelectronics Industry

Introduction

The evolution of the Korean microelectronics industry has, as we shall see, many similarities to the Brazilian experience; in both cases selective state intervention, industrial targeting and protectionist policies such as market reserve and import controls have played a capital role. The dissimilarities, however, in terms of policy orientation, depth, scope and method of implementation are much more stark than the similarities and there n lies the key to understanding Korea's success and competitive edge as compared to Brazil.

In what follows I shall seek to unearth the reasons behind Korea's success and shortcomings in the development of its microelectronics industry comparing and contrasting its experience where appropriate with that of Brazil's. For reasons cited earlier, in Chapters Two and Three, emphasis shall be placed on the role of the state entailing an examination of the micro and to a lesser extent macro policy measures related to the development of the microelectronics industry. Subsequently I shall examine the industry's structure and evolution with an eye to its competitive capacity comparing it, where appropriate, to Brazil's microelectronics industry. Since the Korean microelectronics industry is a direct outgrowth and integral part of the electronics industry I shall begin with a discussion of the evolution of the electronics industry in the way of a background.

Background: The Electronics Industry

Prior to the early 1980's Korea possessed little indigenous microelectronics manufacturing capability and its domestic activities were for the most part confined to the OEM of semiconductors and electronics products under license to foreign firms. Such activities, however stimulated the development and rapid growth of an export oriented electronics sector out of which the microelectronics industry grew. As such, Korea's foray into microelectronics should not be regarded as a dramatic new departure but rather as a reflection of Korea's desire to restructure and upgrade her electronics industry to a higher level of technological intensity. This point reveals a fundamental difference between the strategy pursued by Korea in microelectronics and that pursued by Brazil. As we saw earlier Brazil's strategy was one of backward building; that is it began with incentives for the production of downstream informatics products, namely computers, and then worked backward to the development of semiconductor capabilities. In contrast Korea's strategy has been one of forward building; that is state policies and corporate strategy have focused on existing capabilities, namely in consumer electronics, and built forward into semiconductors and subsequently into the production of downstream informatics products. Therefore, in order to understand the evolution of the microelectronics industry it is essential to undertake first a brief survey of the electronics industry as a whole.

The Korean electronics industry got underway in the early 1960s with the assembly of vacuum tube radios with imported parts under the import-substitution strategy in effect at the time. Up to the middle of the 1960s the industry was dominated by domestic capital comprised of some 40 odd firms

with a combined output of only \$14 million in 1965. In 1965, however, the government's enactment of the Foreign Capital Inducement Law combined with the abundance of skilled labour and low wage rates resulted in an influx of foreign capital into the industry. Combined with the new military government's export expansion strategy for industrial development, the electronics industry began its takeoff. In 1969, the government, recognizing the strategic significance of the electronics industry in terms of its export potential, gave its full scale endorsement to the industry with the enactment of the Electronics Industry Promotion Law, which targeted the electronics industry as one of the priority industries for development. The law laid out a comprehensive eight year development program for the industry geared primarily to the development of assembly operations for black and white televisions.

By the early 1970s the assembly of black and white TVs and the manufacture of parts and components such as transistors and integrated circuits dominated the industry. 1974 marked the beginning of the rapid expansion of the consumer electronics sector dominated by domestic capital. The expansion was fueled primarily by the production of colour TVs which were given the same high priority and support by the government as the assembly of black and white TVs were given in the late 1960s. By the late 1970s the Korean electronics industry was producing a variety of consumer electronics products ranging from electronic calculators and watches to VCRs; in 1979 Korea became one of only four nations in the world with the technological capabilities to produce VCRs.

In the early 1980s the bulk of Korean electronics was focused on the production of such items as colour TVs, audio systems, VCRs and the newest addition: microwave ovens. Much of this production took place on an OEM basis, primarily for Japanese electronics firms such as Toshiba and Sony and to a

lesser extent U.S. and European firms. These OEM linkages were supplanted by manifold technical linkages, with the Japanese acting as technology donor and the Koreans as technology recipients. Often such OEM-technology transfer arrangements were cemented through formal ownership ties involving joint-ventures, thus enhancing the contractor-subcontractor relationship. Such sustained symbiotic relationships with Japanese firms enabled Korean firms to garner much in the way of production know-how and product licenses in such areas as facsimile machines, PCs, VCRs, robotics, silicon wafers, computer optics and in a host of other areas spanning the gamut of consumer and industrial oriented electronics.¹⁴³

Whereas wholly domestic-owned firms dominated in the area of consumer electronics this was not the case in the area of computer, semiconductor and peripheral equipment production. In this area foreign and joint venture firms tended to dominate. This began to change, however, in the early 1980s as large domestic firms entered into the production of LSI and VLSI technology.

In 1984 the Korean electronics industry, comprising microelectronics, had an output of \$7.2 billion with a predicted output of \$20 billion in 1991 and \$72 billion by the turn of the century. Taking the figure of \$20 billion as our cue the industry averaged an annual average growth rate of approximately 30 percent during 1971 to 1991. Between 1971 and 1979 the industry grew at the phenomenal rate of 46.4 percent per year outpacing the growth rate of GNP and the manufacturing sector as a whole. Between 1971 and 1983 the share of electronics output in GNP grew from 1.5 percent to 7.6 percent. As a share of total manufacturing output the share of electronics increased from 7.2 percent to approximately one-third over the same period. The growth rates of exports has

been equally impressive. In terms of total exports the share of electronics rose from 8.3 percent in 1971 to 12.5 percent in 1983. In absolute terms electronics exports amounted to a whopping \$11.2 billion and were expected to replace textiles as the nation's leading export item by 1988.¹⁴⁴

Korea's lengthy seasoning in electronics provided it with production and export experience that were to be of great benefit in her microelectronics endeavors. It stimulated the development of a manpower base with technological skills in electronics and helped to foster an awareness of the significance of microelectronics to industrial growth.

The State: Overall Policies and Strategies

Since the early 1960s the Korean state has played a decisive and pervasive role in the economic development of the nation. The electronics and the microelectronics industry in particular have been no exception. Through a variety of policy tools and measures ranging from subsidies to educational and manpower programs, the state has consistently and vigorously encouraged the development of high technology industries particularly microelectronics.

The emphasis which the state has placed on the development of high technology industries, such as microelectronics, is predicated on Korea's conception of high technology given her natural resource endowment: poor natural resource endowment on the one hand and a large pool of skilled and disciplined labour on the other. The development of high technology industries which are energy and resource saving and provide a high rate of value added have been viewed as fundamental to the nation's strategy of maximum

utilization of her comparative advantage.

In the 1980s the emphasis on high-technology industry took on an added urgency. Rising wages in Korea were making it increasingly difficult for Korea to maintain its low cost advantage in light of the greater cost advantage of the second tier Asian and Latin American NICs. It thus became evident that if Korea was to maintain its competitive advantage and thus preserve its position in the dynamic growth pole of the world economy it would have to enter the realm of high tech, high value-added industries in which competitive advantage is based on innovative capability. The implication of this for the electronics industry was expressed in the need and desire to restructure the industry based on a higher level of technological intensity: namely microelectronics technology. This desire is reflected in the Korean Delegation's 1983 report to the Eighth General Assembly of the Asia Electronics Union:

The recent fundamental restructuring of the Korean industrial pattern is attributable mainly to its scanty natural resources, which leaves the country with no other choice but to turn to technology intensive industries represented by electronics. It remains the national consensus that, as a strategic industry designated for the fifth Five Year Economic and Social Development Plan, the electronics industry should play the propellant role in accelerating the pace of economic growth of the nation to expedite achievement of a highly developed economy and a welfare state.¹⁴⁵

In contrast to Brazil, whose microelectronics industry got underway in the early 1970s, Korea's venture into the highly competitive world of microelectronics dates back only to early the 1980s. In 1981 the government revised the Electronics Industry Promotion Law and drew up an executive plan for making the electronics industry a highly advanced industry in Korea. The most notable feature of this plan was the establishment of the Electronics Support Fund (ESF), to be financed jointly by public and private sector

contributions. The size of the ESF was to be W 7.5 billion and was to be lent at preferential rates to firms investing in high priority areas, notably microelectronics. In particular, firms establishing R&D subsidiaries overseas were to be given preferential access to loans.¹⁴⁶

Additionally, the law provided for measures promoting indigenization of electronic equipment, creation of industrial estates, financial assistance of in-house research institutes, and the establishment of the Electronics Industries Association of Korea (EIAK). The primary functions of the association, funded principally by the government, are, to stimulate the industry's indigenization, promote electronics exports and international cooperation and to assist and promote the formulation of industry development plans. One of the most notable of the industry development plans is the Semiconductor Industry Promotion Plan implemented in 1983. The plan featured a variety of measures designed to encourage the development of an indigenous manufacturing capability in semiconductors.¹⁴⁷

The objectives of the Electronics Promotion Law were augmented in 1982 by the Fifth Five-Year Plan which targeted the electronics industry as one of the country's ten major strategic export industries. The major features of the plan concerning the electronics industry were:

- "1. Increase the value added and international competitiveness of home [consumer] electronics products.
2. Priority development of a brain-intensive, resource saving electronics industry based on a higher level of technological intensity, namely microelectronics.
3. Developing and achieving self-sufficiency in the production of industrial electronic equipment.
4. Domestic development of the principal electronics parts and components [notably semiconductors]."¹⁴⁸

The plans outlined above should be viewed as being indicative rather than imperative in nature, i.e. private sector activities have not as a general rule been strictly determined by administrative fiat but have been steered by material incentives (subsidies) into the desired sectors and development paths. To this end a comprehensive arsenal of incentives was created and from time to time adjusted to encourage and ensure the development of a highly competitive microelectronics industry. Additionally, the state has set comprehensive macro frameworks for the education system and for the national research laboratories. In what follows I shall undertake an examination of these incentives as they pertain to our study.

Foreign Investment:

Foreign investment in Korea is governed by the Foreign Investment Inducement Law (FCIL), first inaugurated in 1963. A central purpose of the FCIL has been to induce and direct the flow of foreign investment into Korea. It has done so primarily by authorizing substantial tax benefits to eligible foreign investors. According to Chung as of March 1984 cumulative foreign investment since 1962 amounted to 974 projects with a cumulative value of \$1.753 billion.¹⁴⁹ Japan was by far the principal contributor with 68.8 percent of projects and 48.6 percent in terms of value, followed by the U.S. with 18.5 percent of projects and 27.7 percent of value. Of the cumulative total 19.7 percent of the projects (192 cases) and 15.0 percent of the value (\$262.9 million) was in the electric and electronics industry, a break down of which, in terms of foreign equity investment, is provided in table 5.3.

Korea has historically sought to limit wholly owned FDI in its industries, opting instead for majority Korean owned or 50-50 joint ventures. Of

Table 5.3: Electrical And Electronics: Foreign Equity Investment (Approvals) By Share Of Investment, As Of August 1983 (Cumulative From 1962)

Equity	Value	Percentage of total	No. of new projects	Percentage of total
1-49	63.8	24.3	59.0	31.0
50	15.8	6.0	62.0	32.0
51-99	22.0	8.4	23.0	12.0
100	161.3	61.4	48.0	25.0

Source: Adapted from: "Korea: Managing the Industrial Transition," *World Bank Country Study, 1987*, 206.

all electronics-related foreign invested projects 63 percent were in those two categories (Table 5.3). However, those projects represented only 30 percent of the total equity whereas wholly owned FDI, which accounted for only 25 percent of the number of projects accounted for 61.4 percent of the total equity invested.

In 1983 the government revised the FCIL, thus liberalizing its regulations governing foreign investment. The revision was carried out with an eye to increasing the flow of FDI, thus enlarging the flow of foreign technology. The revisions had special significance for the electronics and microelectronics sector given the importance of FDI as a source of technology in this sector. The most significant revision was the switch from a positive to a negative list system under which all areas are considered open to investment unless specifically prohibited. However, certain restrictions on FDI remained in place. The most significant as far as the electronics and microelectronics sectors are concerned is that wholly foreign firms in these two sectors are to export at least 50% of their output. Most joint ventures on the other hand can sell all of their production domestically. Despite the remaining restrictions, the liberalization has led to an

upsurge in FDI in Korea's electronics industry in recent years.¹⁵⁰

Educational Policy:¹⁵¹

Korea's rapid success in electronics in the 1970s and microelectronics in the 1980s is to a large measure attributable to the existence of a superior and large labour force, whose skills stand up to comparison with those of the industrialized countries. This is due to the high priority which the government has placed on the educational system as reflected by the share of education in total government expenditure. During the 1980s expenditure on schools, colleges and universities accounted for between 14.9 and 20.1 percent (1986) of total government expenditure, which means that education in 1986 ranked second behind expenditure on national defense (30.2) percent. Translated in terms of GNP the respective percentages varied between 4.0 percent and 4.5 percent. Such large investments are yet another reflection of the country's natural resource endowment.

In quantitative terms the country's educational system can measure up to that of most industrially advanced nations. More than 98 percent of all children reaching the age of compulsory education receive six years of elementary schooling and more than 95 percent three additional years of middle school education. Almost 90 percent undergo further education in general (3 years) or vocational high school. Most impressive, however, is that more than one quarter, 26.4 percent in 1983, are registered with institutions of higher learning (junior colleges, colleges and universities).

The above figures are exclusive of private vocational training which has played an important role in providing skilled manpower. Systematic planning of vocational training began in 1966 with the passing of the vocational training law.

This was followed in 1974 by a law which made it mandatory for all firms employing 300 or more workers to provide in-house training. Generally, such training programs were not subsidized by the government. To comply with the law, many firms established their own vocational training institutes which trained approximately ten percent of the work force annually.¹⁵²

In electronics, formal education begins at the technical (vocational) high schools and is followed by two years of junior technical college. Most engineering colleges, through their departments of electronics, offer courses in research, laboratory work, and field training in electronics. In order to meet the requirements of the emerging informatics industry many universities have begun to provide courses in computer technology and theory. Middle and high schools have also incorporated fundamental computer technology courses as part of the regular curriculum.

Beyond the academic institutions there are a number of public and private research/training institutes to consider. The Korean Advanced Institute of Science (KAIST) offers graduate work in a wide variety of subjects including electronics. Additionally, KAIST along with other public research institutes such as the Korea Institute of Electronics Technology (KIET) and the Electro-Technology and Telecommunications Institute (KETRI) provide electronics engineers with support and access to research, study and laboratory work. Many major electronics firms also operate their own in-house R&D institutes which support R&D personnel and train technical personnel.

Under the Semiconductor Industry Promotion Law of 1982, training programs have been instituted to ensure a supply of highly skilled labour for the VLSI and other related projects. During the 1980s, Korea plans to produce 1,360 semiconductor and 820 computer experts.

Despite the government's and industry's laudable efforts there remain certain shortages of highly experienced personnel particularly in the area of engineering design and project management. To overcome this obstacle both government and industry have resorted to overseas training. The state has done so through the use of scholarships for the training abroad of graduate scientists.¹⁵³ Korean firms have done so through the inclusion of intensive training programs in technology acquisition and joint venture programs with foreign firms; examples include arrangements with AT&T and ITT.¹⁵⁴

The combined efforts of the public and private sector have resulted in a trebling of the stock of R&D personnel between 1976 and 1984. During the same period the allocation of financial resources from government and private sources rose by eight fold.

In comparison to other NICs such as Brazil, India and Mexico, Korea, in the late 1970s had the "highest number of secondary students as percentage of secondary school age population; engineering students as a percentage of the total post secondary school age population; scientists and engineers per million people and scientists and engineers in R&D per million people."¹⁵⁵ Moreover, in comparison to the Latin American NICs, including Brazil, educational institutions have been quite flexible in adapting to the demands generated by the restructuring of the economy and the changing skill composition of the work force.¹⁵⁶

Research and Development:

R&D expenditures have been rising steadily in recent years both in absolute and relative terms to the size of the GNP. Total R&D expenditures reached a level of 2 percent of GNP in 1990 from a low of 0.44 percent in 1976.

The sharpest increases occurred in the early to mid 1980s clearly reflecting the government's and industry's objective of restructuring the Korean economy to one based on a higher level of technological intensity. What is of interest, however, is that the relative share of private R&D has been steadily expanding and in 1984 accounted for some eighty percent of the total, compared with roughly equal private/government shares in 1980 (Table 5.4). This development is of importance because it is the private sector which is primarily responsible for using the results of R&D research to improve productivity. Of greater significance, however, is that within the context of my earlier discussion in Chapter Three regarding learning by using, this development implies the development of a close link between learning by using and the development aspect of R&D. This is because in the development aspect of R&D, as argued in Chapter Three, learning is oriented toward the commercial dimensions of the innovation process and therefore best carried out by the private sector. This contrasts to the Brazilian case where the lack of private R&D has been partly responsible for inhibiting the development of such a link.

Despite the government's declining share in total R&D expenditures it continues to play an important role in the electronics and microelectronics industry due to the high R&D costs involved and the growth of high tech neo-mercantilism which, as noted in Chapter Two, has made it increasingly difficult to acquire foreign technology. Given the microelectronics industry's dependence on imported components this has necessitated the development of a strong R&D infrastructure.

In the early 1980s sixteen government-funded research institutes were merged to form nine institutes responsible exclusively to the Ministry of Science

Table 5.4 Expenditure On Research And Development, 1976, 1980, 1984, 1990.

Year	R&D expenditures ^a (in U.S. \$ millions)			Ratio C/A percent	Share of A in GNP percent
	Total (A)	Government (B)	Private (C)		
1976	125.8	81.5	44.3	35.2	0.44
1980	348.6	179.9	168.7	44.8	0.57
1984	1007.8	215.3	792.5	78.6	1.26
1990	3500.0	-	-	-	2.0
2000 ^b	-	-	-	-	5.00

^a excluding military and defence

^b predicted

Source: Adapted from: UNIDO: "The Republic of Korea," 62.

and Technology (MOST). Prior to the mergers these institutes were under the control of various government ministries.¹⁵⁷

Given the high and often risky R&D costs associated with the development of high technology industries, particularly microelectronics, for reasons discussed in Chapter Two, the mergers were seen as a means to permit a more rational and efficient operation of these institutes with regard to exchange of researchers, joint utilization of facilities, joint research undertakings, joint utilization of R&D results, and administrative support. The pooling and coordination of R&D resources and activities has greatly reduced redundancy and enabled Korea to achieve economies of scale in R&D. This, as shall be exemplified later on in my discussion of the industry's evolution, has played a crucial role in Korea's rapid success in microelectronics.¹⁵⁸

The government's R&D efforts in the fields of electronics and microelectronics are channeled through three principal public research institutes, KAIST, KIET and KETRI.¹⁵⁹ The latter two are offshoots of KAIST whose

activities were discussed earlier. In addition, the government funds joint industry-government research projects in microelectronics, new materials and systems engineering.

KETRI first got involved in microelectronics with the establishment of a semiconductor production facility in Gumi in 1976 to stimulate the development of the domestic computer and semiconductor industries. In 1983 KETRI sold the facility to the private sector in order to concentrate on research and development.

KIET was established in 1979 with funding from the World Bank which was matched by the government. KIET's primary mission is to spearhead the government's R&D efforts in the area of microelectronics technology centered around integrated circuits from design to fabrication. It develops semiconductor device prototypes and process technology and has established a national center for automated semiconductor designing and a training center for electronics technicians. Moreover, under the auspices of the KIET the government conducts basic semiconductor design work, which is then passed on to the various companies who adapt the design for their own particular purposes.¹⁶⁰ In line with the government objective of global technological sourcing the KIET maintains an office in California's silicon Valley which is used for design and liaison with VLSI Technology, a U.S. company. In addition to its in-house research efforts the KIET also sponsors industry-government development projects in the semiconductor, computer and software fields. Examples include the development of video tape recorder chips and 8 bit, 16 bit and most recently 32 bit processor technology.

To ensure the commercialization of the research results of the public R&D institutes the government in 1979 established the Korea Technology

Advancement Corporation (K-TAC) as a subsidiary organization of KAIST. The K-TAC links research results with the private sector through the translation of R&D into practical applications.¹⁶¹

A central role of the public R&D institutes is to assist the private sector in the successful transfer and assimilation of imported technology. Technologies, either relating to product or processes, deemed to be of strategic nature, particularly in the case of microelectronics technology, are often pooled at national R&D institutes so that they may be broadly diffused throughout the private sector. For example, a firm that has contracted foreign technology through a technology acquisition agreement would be required to transfer that technology, if deemed strategic, to a national R&D center so that it may be made readily available to other firms requiring it. By pooling and sharing strategic technologies Korea has managed to reduce technology acquisition and development costs by curtailing redundant R&D activity and technology imports.

In the same vein the government has sought to nudge the country's leading electronics manufacturers into a greater degree of cooperation in microelectronics. While the chaebol have shown some reluctance in exchanging secrets, they have been persuaded by the government of the necessity of cooperation in light of the staggering R&D costs and shortening product life cycles associated with microelectronics technology. As Business Korea has observed

All companies in the Korean semiconductor industry are in the same boat with the same goal to compete with advanced countries for the sake of the country's future. It is not important for one company to gain an edge over other members boarding the same boat since its competitors are in different boats in foreign nations.¹⁶²

The most notable example of cooperative R&D in the microelectronics industry is the Korean Semiconductor Cooperative Research Project known better as the VLSI project. Launched in 1986 by KETRI, the VLSI project is by far the largest and most ambitious industry-government R&D project undertaken in the microelectronics industry. The project's primary objectives are the development of 4 megabit memory technology and a variety of non-memory and upstream technologies. To this end the project is divided into three separate committees each with its own set of objectives (Figure 5.1). The project's total funding of \$119 million is borne equally by government and industry, although the industry's share is heavily subsidized by government-guaranteed low interest loans.¹⁶³

R&D projects such as the VLSI have served to make Korea a highly viable competitor in the global microelectronics industry. However, Korea cannot nor does it expect to achieve technological parity with the advanced industrial nations for some time to come. In the meantime it will have to continue to rely on the imports of technology in order to maintain and buttress its competitive position in microelectronics technology.

Technology Imports:

In contrast to Brazil Korea's stance towards technology imports has been more liberal.¹⁶⁴ This stems from the fact that Korea, unlike Brazil, has been not so much concerned with the mastery of technical innovation as with achieving and maintaining its competitive position in the world market. Hence in the process of developing its microelectronics industry Korea has forgone the route of self-sufficiency and has relied heavily on importing and adapting foreign technology in both the semiconductor and computer sectors.

Figure 5.1

Source: Howell, 161

The principal means for obtaining foreign technology have included FDI, joint-ventures, and licensing agreements. In the early years of the industry the principal source of foreign technology was Japan. However, Japan has increasingly come to view Korea's success as a threat and in recent years has resisted transferring technology for fear of a boomerang effect, in which the commercial rival comes to use the company's own innovation to grab shares of its markets. Consequently, Korean firms have come to increasingly rely on alliances with American firms for their technology needs. I shall elaborate on this later on in my discussion of the evolution of the Korean microelectronics industry.

Protectionist Policies:

Like Brazil the Korean government has employed a variety of protectionist measures, such as market reserve, import controls and tariffs, to protect its budding informatics industry. In the early 1980s the Korean government imposed an import ban on foreign made electronics. This meant that the only way in which overseas electronics products could penetrate the growing domestic market was by producing those goods in Korea by means of wholly owned subsidiaries, joint ventures, or licensing agreements. The last two, in particular, have been utilized by foreign manufactures, especially in semiconductor production (eg. the Goldstar-AT&T joint venture and the Intel-Samsung and INMOS-Hyundai licensing agreements).¹⁶⁵

Unlike Brazil, however, these measures have been highly specific in their application, firmly time bound and implemented in accordance with the capabilities of domestic firms. The specificity and time bound nature of these measures has helped to foster a competitive and innovative environment for

informatics firms and discourage complacency. As a consequence Korean firms have been quick to learn the necessity of garnering production experience, scale economies through increased share of the domestic market, and developing innovative capabilities as quickly as possible in order to meet the challenges of foreign competition and the exigencies of the international market. This is clearly reflected in the stupendous sums spent on electronics related R&D as discussed above.

Most of the government's efforts at protecting the domestic informatics industry have been concentrated in the downstream sectors of the industry, particularly the computer sector. In 1982, the Korean Ministry of Trade and Industry (MIT) issued regulations which effectively barred the import of micro and minicomputer systems and peripherals and additionally provided for measures to encourage the transfer of foreign technology to Korean firms.¹⁶⁶ The intent of the import controls was to create a protected market in which local firms could develop their technological capacities and production experience in computer manufacturing.

In 1987, less than five years after their implementation the import controls were lifted. In this short period of time however the Korean government's protectionist measures in computers had proven enormously successful, with Korean small computers making substantial inroads in the world market.

Strong controls on foreign investment in the electronics industry prior to the 1980s have also played an important role in nurturing the early development of the microelectronics industry. The phasing out of these controls in the early 1980s, which coincided with emergence of the microelectronics industry has led some authors such as Kim et al to imply that they were of little significance in

the development of the computer industry.¹⁶⁷ However, as Copley points out such restrictions had an important indirect role in the development of the industry. The restrictions essentially served to reserve the market and provide a hot house environment for domestic firms to flourish in. Thus the restrictions on foreign investment facilitated and encouraged the domination of the industry by a small number of large, diversified conglomerates (chaebols) and were crucial to these firms' development of production and innovative capabilities and bargaining strength based on activities in other facets of the electronics industry, particularly consumer electronics.¹⁶⁸

Subsidies:

Government subsidies may be construed as yet another form of protectionism in so far as they single out and target specific national industries and/or firms for favorable treatment over foreign firms. As outlined in the previous discussion of the Brazilian microelectronics industry, government subsidies have been used extensively in Brazil to stimulate the development of the informatics industry. In Korea, however, as Amsden notes in contrast to Brazil

the state has exercised discipline over subsidy recipients. In exchange for subsidies, the state has imposed performance standards on private firms. Subsidies have not been give aways, but instead have been dispensed on the principle of reciprocity. With more disciplined firms, subsidies and protection have been lower.¹⁶⁹

The electronics and microelectronics industry have been no exception to this treatment. As noted earlier the electronics industry, which comprises the microelectronics industry, has been classified as a key strategic industry and therefore has benefitted from a variety of government assistance programs. The

most notable of these programs are summarized below.¹⁷⁰

Tax Incentives: Various forms of tax incentives are used by the government to assist the electronics and microelectronics industries in the development of technological capabilities and markets. These include: depreciation allowances, tax deductions from capital investments and exemptions from R&D investments, reductions and import taxes, and the establishment of reserves for investment and the development of overseas markets. The most notable of these include exemptions on R&D outlays and crucial imports.

Exemptions associated with R&D activities and human capital development (training programs and the like) are tax deductible. Moreover, under the Technology Development Reserve Fund, companies are allowed to set aside 20 percent of each years pre-tax profits for R&D use in the following two years. Tax incentives are also offered to private R&D centers and cooperatives. They include the exemption from local tax and from import tariffs on R&D related equipment.

Tax reductions are applicable on imports of industrial equipment for IC production and on imports of crucial components not available in Korea. These tax reductions have been particularly important in the development of the microelectronics industry given its high reliance on component imports. This dependence shall be discussed later in my discussion of the industry's evolution.

Financial Assistance: In addition to tax incentives, financial assistance programs have also been used to aid the development of the microelectronics industry. These include the electronics industry development fund (discussed earlier), preferential financing for investments in production systems and prototype development¹⁷¹ and for investments utilizing locally produced capital

goods.

In addition to financial assistance programs geared specifically to the microelectronics industry, assistance programs geared to other industries need also be taken into account. As Todd has pointed out, the diversified industrial activities of the conglomerates that dominate the electronics and microelectronics industry has enabled them to cross subsidize government assistance to other industries in which they are active, most notably steel automotive and shipbuilding, to enhance their electronics divisions.¹⁷²

Financial and tax incentives have also played an important role in ensuring the export orientation and global outlook of the microelectronics industry. This outlook, as shall be elucidated shortly, has been a key factor in the successful development of the Korean microelectronics industry and, as alluded to previous chapters, it is a key factor in distinguishing the Korean experience from the Brazilian experience.

Demand:

The government's most direct influence on demand conditions in the microelectronics industry has been through procurement.¹⁷³ Government procurement has played a pivotal role in the development of the computer sector by creating an early and guaranteed demand base for new entrants into the sector. The government's first procurement contract involved the purchase of 5000 personal computers for public schools in 1983 with the commitment for more orders thereafter. The contract attracted a number of new entrants and encouraged the intensification of R&D activity by the existing firms. Later on in 1983 the government announced a much more substantive procurement contract involving the establishment of the National Administration Information System.

The contract's total value amounted to US\$725 million to be completed by 1995. Other notable computerization projects have included the computerization of the 1988 Olympic Games, the nation-wide banking system, the tax system and the educational research network system amongst others. The investment in each of these projects has been equivalent to that of the Administration project. In accordance with its policy of reciprocity, noted above, the government sets stringent technical specifications and targets for the local content ratio of each product and rewards firms that meet the requirements. Such a measure is designed to induce firms to acquire the technological capability needed to innovate. The specifications are set with reference to international design and performance standards. This has the effect of interfacing domestic demand with global demand and thereby making domestic firms more competitive in the global market.

In addition to government procurement the state has indirectly affected demand conditions in the industry by its influence on macro demand conditions. In recent years the government has increasingly encouraged the expansion of the domestic market as means to absorb more imports and appease calls, particularly by the U.S., for trade liberalization and as part of its strategy to restructure the economy from one based on low cost labour to one based on innovative capacities.¹⁷⁴ To this end the government has cut personal income tax for low and middle income groups and reduced the price of gas and heating oils by 10-12 percent and more importantly encouraged increases in the real wage rate. As a result an increasing share of GNP growth since the late 1980s has been attributed to the growth of domestic demand.¹⁷⁵

The effect of these measures on demand in the electronics industry became apparent in the mid 1980s when there emerged for the first time a

domestic market for electronics, primarily consumer electronics, greater in size than the export market pertaining to these products. Massively augmented sales of electronics products in the home market offered the chaebol a welcome bastion of stability from the instability posed by their previous high export dependence.¹⁷⁶ Equally importantly is that as the domestic market grew it provided electronics producers with a testing ground for their products, prior to export. Thus, reliability standards and the speed with which the product could be delivered to the market were increased and in turn so was the competitiveness of Korean producers.¹⁷⁷

Industry Structure and Markets:

The structure of the Korean Microelectronics industry differs substantially in several respects from the Brazilian microelectronics industry. These differences and their significance are discussed below as a prelude to the ensuing discussion of the evolution of the microelectronics industry.

First, unlike the Brazilian informatics industry where state enterprises spearheaded by a national champion play a prominent role, the Korean industry is dominated entirely by the private sector. The private sector orientation in Korea stems essentially from two elements. The first and most important factor is that the Korean state has historically opted in favour of indirect intervention using mechanisms such as the financial system, as revealed in Chapter Four, to achieve its economic objectives. The second element is that Korea's long experience in consumer electronics provided the private sector with a sufficient technological and manufacturing foundation upon which it could establish a

higher level of technological intensity in the field of microelectronics. In Brazil, however, where the consumer electronics industry is dominated by multinational firms with little to no linkage to the informatics industry, such a foundation was lacking. This void combined with the state's leaning towards ownership to achieve its economic objectives resulted in the high public sector orientation of Brazil's informatics industry.

The second factor which serves to distinguish Korea's informatics industry from its Brazilian counterpart is its structure. Whereas in Brazil the industry is comprised of a large number of relatively small firms, in Korea it is dominated by a very small number, four to be specific, of large, vertically integrated and diversified conglomerates (chaebol). These four are Samsung (the largest) Hyundai, Lucky Goldstar and Daewoo.

Traditionally, state policies by favoring the chaebol have helped ensure the integrity of the small (in absolute terms) domestic market. Consequently, the relationship between industry structure and market size is highly congruous in Korea in contraposition to Brazil where, as shown earlier, the existence of numerous small firms has resulted in the fragmentation of the small domestic market.

The large size of these firms has enabled them to reap economies of scale in production as well as in R&D, giving them sizeable financial resources from which to fund the increasingly large investments required to remain competitive in the microelectronics industry. Moreover, their diversified product portfolios has enabled them to cross subsidize investments in higher risk projects from the revenues earned on established products with high profit margins. Additionally their large asset base has provided them with privileged access to capital markets to raise funds for major new projects such as the VLSI scheme. Finally,

their vertically integrated structure has provided them with a guaranteed internal demand and supply base reducing their vulnerability to external demand and supply shocks common to the microelectronics industry as discussed in Chapter Two.

Foreign firms have also played a prominent role in the industry. However, their activities have, thanks to government restrictions on FDI discussed earlier and the dominance of the chaebol, been restricted primarily to exports. The exception, however, is joint ventures which, as noted earlier, are permitted to sell in the domestic market.¹⁷⁸

The third element which serves to set the Korean informatics industry apart from its Brazilian counterpart is its orientation. In contrast to the highly inward oriented nature of Brazilian informatics firms, the orientation of Korean firms has been highly outward oriented. This has been due to principally two factors: the overall export orientated industrialization strategy adopted by the state, and the small absolute size of the domestic market. As the first factor has already been addressed in the previous Chapter I shall limit my discussion here to the second.

To maintain cost competitiveness in light of the staggering investments required in R&D and production facilities it was necessary for the major informatics firms to turn to exports. Thus they were able to achieve greater scale economies in R&D and production, thereby effectively reducing average variable costs and investment risks.¹⁷⁹ As noted earlier, while the relative size of the domestic market for electronics products had increased substantially, and thus alleviated the dependence of electronics firms on exports, the absolute size of the domestic market necessitated that they turn to exports to achieve the scale economies necessary to maintain competitiveness in the microelectronics

industry. Unlike Brazil, Korea was not blinded to domestic market conditions by ideological blinders of self-sufficiency. This, as discussed in Chapter Four, stems from how each viewed integration into the global economy and its upshot, the international division of labour. Korea, as noted, viewed integration as beneficial to the development of industrial/technological capabilities whereas Brazil viewed it as limiting the ability of the state to successfully control and direct the process of developing industrial/technological capabilities.

The export activity of Korean electronics firms may have also played a crucial role in hastening their development of technological capabilities. As noted in Chapter Three, export activity, by enabling the achievement of scale economies, can speed up the rate at which firms travel up the learning curve and acquire technological mastery thus hastening productivity improvement and efficiency gains. Additionally, the export activity of Korean electronics firms has avoided the zero sum nature of domestic rivalry for market share characteristic of the Brazilian industry.¹⁸⁰

Exports are only one aspect of the overall global strategy adopted by the major Korean informatics firms. As shall be seen shortly, all four major producers have established R&D outposts abroad and three of the four have begun to establish global sales and service networks to market their own products.

Globalization, however, has not been pursued at the expense of developing home based advantages. Rather, it has been pursued as a means to overcome home based disadvantages such as the small size of the domestic market discussed above and to access foreign technology and skilled manpower lacking at home.

The foregoing has attempted to establish the structural background for

my subsequent discussion of the industry's evolution. As shall be seen in what follows the industry's structure has been a key factor in its successful technological evolution.

Evolution of the Microelectronics Industry

Semiconductor Sector

In contrast to Brazil, Korea's early efforts in the development of its microelectronics industry were concentrated in the semiconductor sector. Two factors stimulated the growth of this sector: the demand for computers and the burgeoning growth of consumer electronics.

It was not until the late 1960s that the first computer, an IBM mainframe, was installed in Korea for use by the government in the development of its economic plans. It was more than a decade later, the late 1970s, that private business began to utilize computers. As computer use spread and the Korean economy grew, the domestic market for computers and their peripherals began to grow rapidly.¹⁸¹ Realizing the growing potential of the domestic informatics market and exports many indigenous electronics producers, particularly those engaged in consumer electronics, began to supply these hardware needs by producing components and establishing assembly plants under foreign licences or technical cooperation.

Indigenous semiconductor production was also stimulated by the expansion of the consumer electronics industry. The expansion was fueled in large part by the development of indigenous capabilities in the manufacture of such sophisticated popular products as VCRs and microwave ovens. These products marked the dawn of a new generation of consumer electronics

products employing digital IC technology; as discussed in Chapter One this is essentially the same technology employed by computers and their peripherals.

The private sector initiative to develop the semiconductor industry occurred almost simultaneously and in line with the government's desire to upgrade the electronics industry based upon a higher level of technological intensity as reflected in the EIPL and the Fifth five-year plan discussed above. One year after the introduction of the Semiconductor Promotion Plan, discussed earlier, the giant chaebols of the Korean electronics industry were swept by a fever for investment in microelectronics production. In 1984 three of Korea's largest chaebols, Samsung, Lucky-Goldstar and Hyundai made a massive commitment to enter semiconductor manufacturing. These firms acquired foreign technology and invested astounding sums (estimated at \$1-2 billion) in establishing domestic manufacturing facilities including large scale wafer fabrication and test facilities.¹⁸²

While such investments were considered highly risky, particularly in light of shortening product life cycles, the chaebols' diversified structure provided them with the resources to incur sustained losses, if necessary, in their semiconductor operations, without being driven from the market. This is precisely what happened.

The Korean firms entered mass production of 64K DRAMS at the very moment that the semiconductor sector was entering a severe recession marked by over supply. The Japanese industry had just begun an aggressive pricing strategy (dumping) in precisely the same areas that the Koreans had concentrated their resources (memory products). The aim of the Japanese strategy was to increase their share of the world market by exterminating the competition. To their dismay the Korean producers found that Japanese 64K

DRAM prices were less than half their production costs and consequently the Koreans incurred substantial losses.¹⁸³

The experience was a sobering one for the Korean firms and led to a revaluation of their strategy. It became evident that to avoid the Japanese strategy of extermination, the industry would have to diversify. Rather than concentrate investment solely in the production of memory devices the industry would diversify investments into the production of logic circuits, processors and ICs for use in consumer electronics products such as calculators and electronic watches. Diversification of the industry would be accompanied by specialization by major firms. This would not only bring about greater scale economies but would encourage greater inter-firm cooperation by lessening internal competition.¹⁸⁴ The major firms were essentially in the same boat and the challenge now was to formulate a unified front in the face of fierce foreign competition on the world market. Finally, and perhaps most importantly, it became evident that the government would have to play a larger role in fostering the development of the microelectronics industry.

It was within the spirit of this new strategic framework of cooperation and greater government involvement that the VLSI project described earlier was launched. Individually, between 1987 and 1989 Korea's three largest semiconductor companies invested more than US\$2 billion in chip making factories.¹⁸⁵ The government for its part provided preferential access to capital and reduced custom duties on imported equipment amongst other forms of assistance such as support for R&D and tax incentives discussed earlier.

These efforts were supplemented by investments made abroad within the context of the global strategy pursued by major firms. To gain access to leading state of the art technologies and critical manpower all four of Korea's

leading chaebols in the microelectronics field established subsidiaries or joint ventures in silicon valley. Tristar, Samsung semiconductor's U.S. subsidiary, for instance, played a crucial role in expediting the transfer of 64K DRAM technology from the U.S. firm Micron Technology.¹⁸⁶ Additionally, Korean firms were successful in their bid to establish joint production alliances with American manufactures resulting in technology transfer and training. The American firms entered into these alliances primarily as a means to combat the fierce Japanese competition by utilizing the mass production capabilities of Korean firms. U.S. firms regarded selling technology to Korean firms as profitable, viewing the competition as mainly a Japanese problem. The Korean chaebols' long experience as OEM manufacturers in consumer electronics had enabled them to garner the high quality, reliability and delivery standards which made them ideal partners in the eyes of American semiconductor and computer firms.¹⁸⁷ The establishment of these alliances reflected the success of the global strategy pursued by the industry dominators in supplementing their home based advantages.

The new strategy combined with the stupendous sums invested by the chaebols in production facilities and R&D and the alliances with American firms which resulted in substantial technology transfer in key component areas paid off handsomely. By the latter part of the 1980s Korean firms had begun mass production of VLSI 256K and 1M DRAMs, 16 bit processors and the development of 4M DRAMs following closely on the heels of the advanced countries in terms of technology. By the late 1980s Korea had become the third largest producer of semiconductors in the world with approximately 12 percent of the world market for semiconductors¹⁸⁸ and is "likely to pass the U.S. in 1992 to become the world's No.1 DRAM producer with shipments of about US\$2.5

billion."¹⁸⁹ In 1991 exports in the entire semiconductor sector were expected to rise 10 percent to US\$5 billion.

By employing the Japanese strategy of price slashing or dumping the Korean producers were able to effectively increase their share of the U.S. and European markets. This in turn enabled them to exploit greater learning economies and reduce production costs. This strategy was made possible largely due to the 1986 agreement between Washington and Tokyo that set a floor price for Japanese Chips and thus provided a window of opportunity for South Korean producers. According to Clifford "by the time of the agreement, most U.S. chip makers had left the memory business, leaving the field to the Japanese and the South Koreans. And because they (the South Koreans) were not party to the agreement, South Korean companies were free to undercut their Japanese rivals without fear of provoking a price cutting war." ¹⁹⁰

The feats of the Korean industry in the semiconductor sector clearly reflect the determined and coordinated efforts of government and private industry to forge Korea's economy to one based on high technology and high value added products, both for domestic production and exports, and in the process lay the ground work for a much faster pace in the computer sector.

Computer Sector

The same chaebol that dominate the semiconductor industry also dominate in the computer sector. In the computer sector these firms account for over 60 percent of production and over 90 percent of the government's support for joint research between public R&D institutes and the private sector.¹⁹¹ For these reasons the discussion shall center exclusively on the industry dominators.

The experience that the industry leaders had garnered in the consumer

electronics industry especially in the production of such sophisticated products as VCRs, and Compact Disc Players provided them with a foundation for computer manufacturing. As revealed in Chapter One, these products are based on digital IC technology which is essentially the same technology employed in the manufacture of computers and their peripherals. More importantly, however, has been the parallel efforts of these firms in the semiconductor sector.

As alluded to earlier, in the early years of the microelectronic industry the efforts of the industry dominators were concentrated primarily in the semiconductor sector of the industry. Moreover, these resources, as stated earlier, were almost solely geared to the development of memory devices. Therefore the capabilities of the major producers in the computer sector lagged behind their capabilities in the semiconductor sector particularly in the area of systems design which is based primarily on processor and logic circuit IC technology as opposed to memory IC technology.

As a result of these shortcomings the computer sector was heavily reliant on the import of critical computer components such as processors. In the mid 1980s, however, Korea's capabilities in the computer sector began to improve. The improvement was essentially the result of three factors. The first factor was the intensification in R&D activities on the part of both the government and the private sector stimulated in part by the substantial increase in government procurement discussed earlier. As stated earlier government procurement "attracted many new entrants into the industry and induced aggressive investments and R&D and production by some of the existing firms, marking a major turning point for the computer industry in Korea."¹⁹²

The second factor was the diversification of the semiconductor sector, following the losses in 1984, into the design and production of processor and

logic ICs wherein lies the basis of computer technology. The prior experience of the Korean firms in design and production of memory devices coupled with their new alliances with American firms greatly facilitated this move. As noted earlier, by late 1988, Korean firms had begun mass production of 16 bit processors and by 1990-91 were developing 32 bit processor technology.

The third factor concerned the trend towards convergence made possible by the advent of VLSI technology. As discussed in Chapter Two the trend signalled a shift in value added away from final product manufacture to the components themselves and thus to component producers. Moreover, the trend fostered closer relationships between upstream, midstream and downstream firms resulting in a shift in competitive advantage, technologically speaking, to vertically integrated firms. These developments clearly favored the vertically integrated structure of Korean firms and the technological and cost advantages that they enjoyed in the semiconductor sector.

Prior to the move towards convergence a substantial portion of Korean computer production for exports was based on the basis of OEM manufacturing particularly in the area of peripherals. In the late 1980s, in a bid to capture a greater share of value added the major Korean informatics chaebols led by Samsung electronics began to market their own brand names. The new marketing strategy was the result of four interrelated factors. First, the move towards convergence, which shifted the specter of competitive advantage to component producers and vertically integrated firms. Thus, Korean firms, given their newly acquired capabilities in the design and production of crucial computer components were now in a superior position to become designers of virtual systems (systems based essentially on a single chip). This was not the case when Hyundai's electronics division made its disastrous bid to market its

own product in 1983.¹⁹³

Second, was Korea's lengthy experience as an OEM manufacturer in consumer electronics and computers.¹⁹⁴ This experience not only provided the aforementioned quality and reliability standards to Korean firms but also provided them with invaluable know-how regarding marketing capabilities as a result of their association with brand name producers. As the president of the Computer Brokers of Canada notes "they became so big in (the OEM) business that they decided to start marketing their own products."

The third factor was the rise in labour costs and the increase in the value of the won. After developing an enormous manufacturing capacity, the Korean companies found many of their customers took their OEM business to low-cost economies such as the Philippines or Mexico.¹⁹⁵ Brand name marketing provided Korean firms with the opportunity to recoup some of the losses they had made in their OEM operations.

Fourth was the prior marketing by the chaebol of their consumer electronics products under their own brand names. In doing so the Korean firms gradually established brand name reputations which were to pave the way, by association, and thus facilitate the marketing of their informatics products.

The Korean government gave its full support to the new marketing strategy. As Business Korea reported:

In 1987 the government designated 19 items, including computers and their peripherals, as top of the line products to boost the brand name image of Korean products. A total of 51 companies were designated as makers of top of the line products and supported by the government in their overseas activities. The project is estimated to have been quite successful at marketing Korean brands. The 1988 Seoul Olympics also played an extremely important role in getting Korean brands worldwide exposure.¹⁹⁶

The new strategy resulted in the establishment and expansion of a global sales and service network by the major Korean firms in their major export markets, comprised primarily of the U.S. and the EEC. The costs of doing so were facilitated by the fact that these networks served as agents of the consumer electronics and semiconductor operations of these firms as well. Thus the firms involved in the new strategy were able to realize scale economies in their marketing operations.

The establishment of global sales and service networks in the sophisticated markets of the OECD will no doubt increase the competitive advantage of Korean firms. For reasons explicated in Chapter Three the establishment of such networks will likely enhance the innovative capability of Korean firms by enabling them to more easily decipher and respond to market needs.

Since the beginning of this new marketing strategy Korean firms have made impressive strides into the computer markets of the OECD countries. The principal basis of this success, however, has been the price competitiveness of Korean products as opposed to innovative capability. Korean computers are essentially clones of leading brands such as IBM and NEC and have a technological lag of six months to one year behind the systems of global industry leaders. This technological lag and rising protectionism in the markets of the OECD countries are the major problems facing the Korean industry in its bid to become a world player. These problems are discussed below.

Conclusion: Problems and Prospects for the Future

On several occasions in the foregoing pages I have emphasized the pivotal role that exports have played in the development of the Korean microelectronics industry. Exports have enabled the industry dominators to not only achieve scale economies but, within the context of globalization (set forth in Chapter Three) also to garner the demand efficiencies associated with selling in the more sophisticated and competitive markets of the OECD countries.

In the late 1980s, however, the window of opportunity of Korean firms for exports began to narrow. Two factors were chiefly responsible for this turn of events. First, and most important, was the rising tide of protectionism and technological mercantilism in the OECD countries, particularly in the U.S. Korea's major export market. The tide was, not surprisingly, set off and fueled by the onset of the recession in those countries.¹⁹⁷

As usual the countries with the largest trade surpluses, such as Korea with a trade surplus of \$7.7 billion in 1988, were singled out for the brunt of the retaliatory measures. Ironically Korea's electronics industry was to become a victim of its own success. Heavy anti-dumping measures were imposed on Korean electronics firms, which had prior to late 1980s enjoyed relatively easy access to western markets.¹⁹⁸ Foreign competitors want South Korean producers to set their prices closer to industry norms. In this vein the U.S. has begun to pressure Seoul to enter into a bilateral agreement, similar to that signed with Tokyo in 1987, that would establish a floor price for Korean chips (particularly DRAMs, where the strength of Korean chip makers is concentrated).

To circumvent such trade barriers the major Korean firms have resorted

to relocating production facilities in the West, thus jumping trade barriers.¹⁹⁹ Production facilities have also been relocated to other Southeast Asian countries so as to take advantage of lower labour costs and evade protectionist barriers through third country exporting.

Relocating facilities, however, has not solved Korea's export woes. In 1990 Korea registered its first trade deficit since the recession of the early 1980s, and hit a record high trade deficit of \$9.6 billion in 1991.²⁰⁰ The mounting trade deficits revealed one of the fundamental weakness of Korean industry, particularly the electronics and microelectronics industries: their over-reliance on the U.S. and European markets. To alleviate the problem Korean electronics firms, amongst others, have been actively pursuing trade opportunities in other markets with a substantial degree of success. The two most notable are China and the former U.S.S.R. In 1988 Sino-Korean trade reached US\$3 billion.²⁰¹ China has viewed the trade relationship as a means to alleviate its reliance on the U.S. and Japan for high technology and quality consumer goods. While Korean trade with the Soviet Union was only one-tenth of that with China in 1988 the figure is expected to grow substantially in the years to come.²⁰² Additionally, Korean chip makers have begun increasing their sales efforts in Japan which is eager to buy from South Korean sources.²⁰³ The reliance by Japanese companies on South Korean companies for chips, particularly DRAMs, is expected to increase in the years to come thanks to an ongoing shift in the market for chips that has resulted in stretching the product cycle.²⁰⁴

The rising tide of protectionism has also resulted in slowing down the rate of technological diffusion as evidenced by the emergence of high tech neo-mercantilism discussed in Chapter One. Korea's rapid success in the microelectronics industry has come back to haunt the American and Japanese,

wno supplied the Koreans with technology, in the form of a boomerang effect. The Japanese have become increasingly concerned about the share of the American market in semiconductors and computers that they lost to Korean firms. And the Americans who were once anxious in cooperating with the Koreans, as noted earlier, to beat off the Japanese challenge now find themselves in competition with the Koreans.

As a result of these frictions, owing largely to its own success, the Korean electronics industry has found it increasingly difficult to obtain foreign technology. The situation has been of upmost concern for the Korean industry due to its continued reliance on component imports. While the industry has made formidable technological progress it continues to lag behind the U.S. and Japan in some key component areas pertaining to computer manufacture, notably in processor design technology. Thus, the industry has had to resort to technology imports as a means to maintain the competitive position of its products in the sophisticated and demanding markets of the OECD. In 1988 about 38 percent of Korea's component needs were imported. With a good portion of this coming from Japan, the rising yen has meant higher component costs.²⁰⁵ Moreover, as demand for Korean informatics products has increased so has component imports.²⁰⁶ It should be noted, however, that despite the high rate of component imports the electronics and microelectronic industry is as a whole a net exporter. In 1984 for instance Korea registered a net electronics export of \$1.04 billion.²⁰⁷

The global strategy pursued by Korean firms, involving the location of production and R&D facilities and investing in foreign firms has enabled them to garner a great deal of foreign technology. However, as noted in Chapter Three, the object of a global strategy is to supplement home based advantages

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and not to substitute for them. Ultimately, for Korean firms to maintain a competitive presence in the markets of the OECD they will have to upgrade indigenous R&D capabilities; particularly in capabilities pertaining to component design where as noted earlier the industry lags behind primarily due to a shortage of skilled and scientific manpower experienced in component design. To overcome this shortage greater investments will have to be made in the development of higher educational institutions thus circumventing the need to send students abroad and relying on the recruitment of foreign skilled personnel.

Korea's import reliance is in part explained by the fact, that it, unlike Brazil has placed less emphasis on the technical mastery of innovation and instead opted for importing and adapting more foreign technology. Throughout the 1980s this strategy paid off remarkably well for Korean electronics firms as evidenced in the foregoing pages. Entering into the 1990, however, Korean electronics firms find themselves confronted with a new set of trade and technological variables. Their success has cast them as a clear competitive threat which combined with increased protectionist sentiments has made it increasingly difficult for them to obtain needed foreign technologies.

To maintain and advance on their current competitive position will require that they increasingly rely on their own ideas rather than copy or import semiconductor designs. This may actually facilitate the Korean industry's ability to acquire foreign technology. A stronger indigenous technological base would place the Korean industry in a better position to bargain for foreign technology inasmuch as foreign technology suppliers would have reason to believe that the Korean industry is close to being able to generate the technology on its own. Moreover, technology suppliers are likely to be more forthcoming with

proprietary technological know-how when Korean firms have some technological expertise of their own from which the technology supplier may derive benefits.

If the Korean electronics industry is to maintain its dynamism and secure its position as a major player in the highly competitive global microelectronics industry it will have to pay much greater attention to the development of indigenous technological capabilities and highly trained human capital, particularly in component design. The reality of the situation is that the more successful Korean firms become the more resources they will have to invest to maintain and advance on that position; above all in the area of R&D and human capital development. The battle for competitiveness in high tech industries, such as microelectronics, driven by incessantly fast technological change is a never ending uphill battle.²⁰⁸ Given the success of the Korean industry thus far and the enormous resources at its disposal the odds appear to be in its favour. But the endeavor will by no means be easy.

NOTES (Chapter Five)

80. Raul Luciano Katz, The Information Society: An International Perspective (New York: Praeger, 1988), 101.

81. Paulo Bastos Tigre, Technology and Competition in the Brazilian Computer Industry, (New York: St. Martins Press, 1983), 46, 50.

82. This and the following four paragraphs tracing the motivations for the development of the informatics industry draw on the work of R. Ramamurti, State owned Enterprises in High Technology Industries: Studies in India and Brazil (New York: Praeger, 1985), 239-244.

83. Ibid, 245.

84. For a comprehensive account of the use of the 'tripe' model in Brazil's process of industrialization see: Peter Evans, Dependent Development: The Alliance of Multinational, State and Local Capital in Brazil (Princeton: Princeton University Press, 1979).

85. The inclusion of EEE was based on its prior work with the military as a communications equipment supplier in addition to which it possessed some experience in electronics components.

86. Ramamurti, 251.

87. Emmanuel Adler, The Power of Ideology (Berkeley: University of California Press, 1987), 261.

88. However, it is important to note that the governments original and primary motive in expanding CAPRE's powers was to stem the increasing tide of informatics products into the country.

89. United Nations Industrial Development Organization, Regional and Country Studies Branch Division for Industrial Studies "Survey of Government Policies in Informatics," (UNIDO/IS.526) 4 April 1985, 52-3.

90. Ramamurti, 253.

91. Adler, 248.

92. Tigre, 66.

93. Peter Evans, "State, Capital, and the Transformation of Dependence: The Brazilian Case," World Development, 1985, 795.

94. SID is affiliated with Bradesco, Brazil's largest bank and SID's principal customer for financial automation systems in which SID specializes. Labo is affiliated with Brazilinvest which has a 25 percent stake in the company. Finally, Edissa is owned by the Iochpe group, one Rio Grande do Sul's leading financial institutions. ¹bid. 798.

95. Prior to COBRA's introduction of the 400 series the banking industry's data entry system was provided by Olivetti of Italy. The fact that Olivetti had originally obtained its technology from Sycor was the primary consideration in COBRA's choice of technology supplier. However, COBRA has previously made unsuccessful bids for the technology from Data General and Digital Equipment Corporation, both U.S. companies. Under the terms of the technology transfer agreement Sycor was to provide, in addition to the technological asset, technical assistance and training for installation personnel in the U.S.

96. Ramamurti, 258.

97. Evans, "State, Capital and the Transformation of Dependence," 798.

98. Ibid. Evans goes on to note that had captive firms such as IBM or Digital pioneered the technology they would have had a strong interest in restricting its use by third parties, as a means to bolster their own competitive position. Thus the entry into the microcomputer sector would have been more difficult.

99. Brasil: Trade and Industry Publication sponsored by the Brazilian Ministry of External Relations and by the Banco do Brasil S.A., No.99. (August 1986), 32

100. The decision that IBM and Burroughs should export three computer for every one sold in Brazil should not be interpreted as an export oriented policy per se. To begin with, the decision applied only to the MNCs and not to national firms. Moreover, the primary concern behind the decision was not with developing an export oriented policy but rather with controlling the country's balance of payments and protecting the market reserve policy.

101. SEI's control was subsequently transferred to the Ministry of Science and Technology in 1985. The transfer was part of the transition to democracy and civilian rule that took place in 1985.

102. The use of high technology in the war between the United Kingdom and Argentina over the Falkland Islands further reinforced the Brazilian governments view that defense concerns should accorded a higher priority in the microelectronics industry. Dominguez, 266.

103. Adler, 267.

104. John Westman, "Modern Dependency: A Crucial Case Study of Brazilian Government Policy in the Mini-Computer Industry," Studies in Comparative International Development, Vol.10, No.2 (1985), 46. It was under the directorship of Octavio that IBM and Burroughs were granted permission to

market their midicomputer systems in Brazil.

105. One of the newcomers was Itautec. Itautec is affiliated with Itau, Brazil's second largest bank. As in the case of SID, Itautec specializes in the production of a variety of financial automation systems and its principal customer is the Itau Bank. The other newcomer was a product of a group comprised of Bradesco (SID's affiliate) and Docas do Santos, one of the oldest and largest of Brazil's traditional economic groups. Evans, "State, Capital and ...," 802.

106. "Automated Banking for the Export Market," Brasil: Trade and Industry, Publication sponsored by the Brazilian Ministry of External Relations and by the Banco do Brasil S.A., No.99. (August 1986), 18.

107. In 1984 aggregate demand for IC devices in Brazil amounted to US\$ 179.6 million. Of this amount US\$ 117.1 million was produced locally of which US\$ 27.2 million was exported (92 percent of exports were accounted for by multinationals). The remaining US\$ 90.2 million was supplied by imports in addition to which US\$ 25.3 million worth of inputs had to be imported. The dependence on imports was particularly acute in regard to LSI and VLSI devices. In 1984 these devices accounted for more than two-thirds or approximately US\$ 65 million of the US\$ 90.2 million in imports of all semiconductors. S. Wajnberg, "The Brazilian Microelectronics Industry and Its Relationship with the Communications Industry," United Nations Industrial Development Organization, (UNIDO/IS.546), 5 August 1985, 33.

108. SID is the only Brazilian firm engaged in the production of "State of the Art" semiconductors. Its semiconductor operation, Microelectronica, was founded in 1983 as a result of SID's purchase of Philco, a joint venture between Ford and RCA. At the time of its purchase by SID the venture's production was limited to only linear devices. Ibid., 51.

109. The move to establish production facilities could be made feasible through the exploitation of export opportunities. But such opportunities were not very promising at the time. First, given the technological lag of Brazilian firms in IC production capabilities at the time their products would not be able to compete in the demanding world market. Second, the Brazilian informatics industry's largest export market, Argentina, had begun to launch its own informatics industry and employing protectionist policies similar to those employed by the Brazilian industry. Thus, it was increasingly difficult for Brazilian producers to access the Argentinean market.

110. Wajnberg, 113.

111. Ibid, 76, 120.

112. Brasil: Trade and Industry, 31.

113. Ibid.,14.

114. It was predicted that between 1984 and 1990 the market would grow at an astonishing rate of 30 to 40 percent. Should this prediction hold true the

market will amount to the equivalent of US\$ 12.8 billion in 1990. However, given the slowing growth rates in the 1980s and the uncertain prospects of the Brazilian economy, growth rates in the range of 10 to 20 percent are more likely. With 10 percent growth the market in 1990 will amount to US\$ 3 billion and with 20 percent it will amount to approximately US\$ 5 billion. Claudio Frischtak, "Brazil," in Francis W. Rushing and Carole Ganz Brown, ed., National Policies for Developing High Technology Industries: International Comparisons (Boulder: Westview Press, 1986), 42.

115. Frischtak, 42.

116. It is important to note that this is not a refutation of the market reserve and import control policies in principle but rather a criticism of the timing and manner in which they were implemented. This is discussed in more detail later on.

117. Raul Luciano Katz, 103-104.

118. Katz, 105. CAPRE's encouragement for the use of large systems seems to have been based on two factors. First, since large systems were less expensive than very large systems the burden on the balance of payments would be less. Second, since the power of and capability of mini systems, which national firms were in the process of producing, was close to that of large systems the transition to mini systems by firms who purchased the large systems would be easier once the national firms informatics industry got production of the mini systems underway.

119. Demand remained constrained because there was a complete ban on imports of mini systems. This would not have been the case if tariffs were used instead of an import ban. In a tariff scenario demand could be satisfied but at a higher price. A tariff might have had several advantages over an import ban. First, it would allow the diffusion of informatics technology to continue albeit at a slower rate. Second, the money collected from the tariff could have been used to aid the domestic industry. And third, it might have speeded the development of domestic capabilities by national producers by injecting an element of competition and urgency into the market.

120. Frischtak, 48.

121. For example, The scale of production practiced by most Brazilian microcomputer firms is 1-3,000 units per year, well below the estimated optimal production scale of 50-100,000 units per annum. This scale of production is typical of Korean producers who, as shall be seen in the next section, have successfully managed to exploit the scale economies associated with export activity. Ibid., 64.

122. Frischtak, 51. Additionally, Frischtak notes that the levels of labour productivity, as denoted by the value of output per worker, do not seem to be rising over the period 1979-84. In current dollars they were respectively: 47076, 34856, 44689, 44342, 43663, and 38291.

123. Two factors have been primarily responsible for preventing the consolidation of the industry through such means as mergers. The first and most significant factor has been the restrictions imposed by CAPRE and SEI. As noted earlier, one of the basic criteria of the minicomputer competitions was that the minicomputer firms would not be allowed to diversify into the production of computer products but had to concentrate on the production of the central processing unit (CPU). The purpose of this requirement, as noted, was to avoid excessive market concentration as existed in the large and very large segment of the market, dominated by multinationals. The second factor has been that the small size of the microcomputer firms, resulting from the unrestricted entry of new firms into the market, combined with easy access to the microcomputers technology has made the playing field very even thus making it difficult for one firm to gain an advantage over another.

124. Open architecture systems refer to systems based on discrete devices as opposed to closed architecture systems which are based on ICs. A more detailed explanation is provided in Chapter One.

125. Frischtak, 52.

126. As noted in chapter two, the microelectronics industry is comprised of a highly interdependent integrated fabric, especially since the advent of VLSI technology and the subsequent move towards convergence. Thus any problem in one sector of the industry will result in ripple effects spreading throughout the entire industry.

127. The lack of demand for semiconductor devices can also be attributed to the virtual non-existence of a domestic consumer electronics industry, which as noted in Chapter One is, after computers, the most intensive user of semiconductor devices. Because the industry was never considered relevant to the government's political and defense aspirations, since it was not considered strategic in terms of enhancing national sovereignty, it was never targeted for development. Therefore, as it stands, the consumer electronics industry in Brazil is dominated by multinationals with no linkage to the informatics sector, geared predominantly to export production, with a substantial portion of its component requirements met by imports. Daniel Todd, The World Electronics Industry (New York: Routledge, 1990), 281.

128. By limiting the activities of minicomputer producers CAPRE effectively prohibited the development of vertically integrated enterprises. Consequently, this has been a major factor in retarding the development of scale economies in R&D and production in product lines other than bank automation. Moreover, it has also hindered the development of closer links between the up, mid, and downstream sectors of the industry as necessitated by the trend towards convergence discussed in Chapter Two.

129. Returns to scale refer to the technological phenomena that occur within firms as a result of changes in inputs and the resultant changes in output. Specialization, which involves the ability to combine inputs in more efficient manner as the output rate increases is an example of such phenomena. While economies of scale and increasing returns to scale are related they are not synonymous. The latter is simply the technological basis for the former. Hence it

is possible to have increasing returns to scale but no economies of scale if the firm must buy its input at a price that rises when the industry or firm expands production. Kenneth W. Clarkson and Rodger LeRoy Miller, Industrial Organization: Theory, Evidence and Public Policy (New York: McGraw-Hill, 1982), 363.

130. Similar to Schumpeter's theory of firm size discussed in Chapter One, Nelson has argued that R&D may end in various different results so speculative research in one area may result in discovery in another area. Therefore, the incentive for undertaking and the ability to reap the benefits of such speculative research is higher in large diversified firms. Moreover, an unexpected result may cause further diversification in a firm large enough to fund such an enterprise. Risk is effectively reduced due to diversification and possible expansion. Richard R. Nelson, "The Simple Economics of Basic Scientific Research," Journal of Political Economy, Vol. 67 (June 1959), 297-306.

131. In 1982 the total sum spent by national firms on R&D amounted to US\$ 69 million, a meagre sum when compared to the US \$84 million spent by Data General in the same year or better yet the US \$2 billion spent by IBM in R&D. Frischtak, 64.

132. As Ernst and O'Connor have noted "Another shortcoming of the S&T infrastructure in the quasi-continental economies (as well as in Brazil) has been the high degree of concentration of R&D activities in government laboratories and state enterprises, and a relatively narrow focus of such R&D on defense-related applications."..."Spillovers to the civilian sector have been limited." Dieter Ernst and David O'Connor, "Technology and Global Competition: The Challenge for Newly Industrializing Economies," Development Center of the Organization for Economic Cooperation and Development (OECD), 1990, 70.

133. M. Penalver et al., "Brazil: Industrial Policies and Manufactured Exports," International Bank for Reconstruction and Development. A World Bank Country Report, (1983), 97.

134. For a definition of learning by using see chapter three under the topic of demand.

135. The mini and supermini systems introduced by Brazilian producers in 1985 were 3-4 years behind state of the art technologies. This is a considerable time lag considering the rapid pace of technological change in the industry and the fact that the technology has tended to become ever more complex as the pace of technological change has picked up. Frischtak, 65.

136. Ibid., 58.

137. By the early to mid 1980s the automation of the banking sector was at an advanced stage. According to Jose Maria Gomes Martins all that remained was "the smaller agencies in towns far from urban centers." consequently demand for informatics products designed for financial institutions was beginning to level off and Brazilian firms began turning to exports as means to shore up sales. Brasil: Trade and Industry, 18.

138. In general, OEMs are producers who sell equipment and systems to other manufacturers for marketing.

139. For example, in Japan "OEM contracts have become so common that a 1983 government survey of 300 major corporations in precision instruments, electrical machinery and transport equipment found that virtually all entered in to OEM contracts." Frischtak, 65.

140. For instance, while "IBM's export-oriented OEM purchases from Brazilian manufacturers have increased fairly rapidly from \$5 million in 1984 to \$15 million in 1985 and are expected to reach \$30 million in 1986... they are relatively small... relative to IBM's captive market, having therefore very high growth potential." Frischtak, 67.

141. "Brazil urged to heed U.S. computer warning," The Globe and Mail, November 24, 1987, B19.

142. Ibid.

143. Daniel Todd, The World Electronics Industry (New York: Routledge, 1990), 235. As the 1980s wore on, however, this symbiotic relationship began to show signs of stress. The deterioration was sparked by a campaign on the part of Korean firms to market their own products under own brand names. This brought them into head on competition with Japan in markets once considered the latter's preserve, particularly the U.S. market.

144. Joseph S. Chung, "Korea," in National Policies for Developing High Technology Industries, eds. Francis W. Rushing and Carole Ganz Brow (London: Westview Press, 1986), 148.

145. Ibid., 158.

146. D. M. Liepziger et al., "Korea: Managing the Industrial Transition," World Bank Country Study, (1987), 202.

147. Ibid., 202.

148. Chung, 158.

149. Ibid., 161

150. Liepziger, 205. Liepziger cites a number of examples to support the claim of an upsurge of FDI in Korea's electronics industry. They include investment by Fujitsu Ltd. (Japan), which plans to build a factory to make personal computers, IBM (USA), which in 1985 established Korea Systems Inc. to manufacture and sell IBM personal computers, Hewlett-Packard (USA) which has a joint venture with Samsung to assemble the HP 3000 minicomputer and an Asian personal computer, established in 1984, and Gold Star Fiber Optics, a 50:50 joint venture between Lucky Gold Star and AT&T (USA) established in 1984, amongst others.

151. Information on Korea's educational policy is derived primarily from the following sources: "The Republic of Korea," United Nations Industrial Development Organization, (UNIDO/PPD.29), 1987, 60-62, and Joseph S. Chung, 162.

152. The number of graduates from these institutes increased more than three fold between 1970 and 1980, from 31,600 to 104,500. Ibid., 62.

153. Koreans account for the second largest graduate student population in American universities. David Crane, "From Copy Cat to Innovator Korea's Making It," Challenges, Ontario's Business and Opportunities, Vol.3, No.2, Spring 1990, 27.

154. Kilnam Chun, "State of the Art Series on Microelectronics, No.3: Republic of Korea," United Nations Industrial Development Organization (UNIDO/IS.490) 1984, 26.

155. Linsu Kim, Jangwoo Lee and Jinjoo Lee, "Korea's Entry into the Computer Industry and its Acquisition of Technological Capability," Technovation, No.6, 1987, 286.

156. Dieter Ernst and David O'Connor, "Technology and Global Competition: The Challenge for Newly Industrializing Economies," Development Center of the Organization for Economic Cooperation and Development (OECD), 1990, 71.

157. M. S. Kanthi, "A Compendium of Technology Plans and Policies in Selected Developing Countries," United Nations Industrial Development Organization, 1986 (UNIDO/IS.641), 76.

158. Ibid.

159. The following information on the role of public R&D institutes is derived primarily from: Kilnam Chun, 10-13.

160. Berney, "The Four Dragons Rush to Play Catch Up Game," Electronics Week, 6 May, 1985, 48-52.

161. "Korea," World Bank Country Study, 1986, 130.

162. Business Korea (August 1985), cited in Thomas R. Howell et al., The Microelectronics Race: The Impact of Government Policy on International Competition (London: Westview Press, 1988), 160. This is in sharp contrast to the situation in Brazil where, as noted earlier, rivalry amongst national firms has worked against the undertaking of cooperative R&D.

163. Howell, 160-161.

164. In July 1980 an automatic approval system for imports of foreign technology was adopted under which imports of all types of technology, except for nuclear and defense technology, are approved immediately by the Bank of Korea when the contract calls for a royalty of 10 percent or less for a duration of

10 years or less. Kanthi, 27.

165. Jeffrey Henderson, The Globalization of High Technology Production (New York: Routledge, 1989), 66.

166. These measures were taken pursuant to the Electronics Industry Promotion Law which gave the Ministry of Trade and Industry broad authority "to facilitate the promotion and technological upgrading of the electronics industry in order to enhance its international competitiveness and help develop the national economy." Chung, 159.

167. Kim et al, 279.

168. Brent Herbert-Copley, Industrial Policy and the Computer Industry in Brazil, India and South Korea: Administrative and Political Constraints to Selective State Intervention, Unpublished, 34.

169. Alice Amsden, Asia's Next Giant: South Korea and Late Industrialization (New York: Oxford University Press, 1989), 8.

170. The following paragraphs describing government tax and financial incentives rely principally on the following sources: Chung, 168-9, and Liepziger, 204-5.

171. This form of financing has been primarily geared at alleviating Korea's dependence on parts and components, which amounted to 70 percent of the \$4.5 billion in electronics parts imported in 1986, by improving production capacities. The dependence on imported parts and components has risen as result of production lagging behind the tremendous rise in demand. Such financing has also been instrumental in the development of prototypes in the computer sector where technological capabilities were lagging behind the semiconductor sector in the early to mid 1980s. The situation has improved, however, with the move towards systems integration given Korea's strength in the semiconductor technology. "South Korea: Electronics Industry Expansion Fuels Demand for Components," East Asian Executive Reports, Vol: 10, Iss: 10, October 15, 1988, 21-24.

172. Daniel Todd, 256.

173. Kim et al., 283.

174. As noted in Chapter Three, according to Porter there is a clear correlation between market sophistication and the innovative capabilities of firms. The best indicator of a market's level of sophistication is the level of wages or GNP per capita. The higher the GNP per capita the higher the market's level of sophistication.

175. "Busy Kia Reflects Economic Drive," The Globe and Mail, March 28, 1988, B.18.

176. Todd, 257.

177. It may be postulated that the increase in reliability standards goes beyond the realm of consumer electronics. Since this sector is the second largest consumer of semiconductor devices, the domestic testing ground for such devices also increases as a result of the increase in demand for consumer electronics. Consequently the reliability standards of Korean semiconductor producers and the speed with which they can deliver their products to the global market also increases.

178. Liepziger, 205.

179. In 1985 the export ratio of local and joint venture firms in the computer sector was 71.2 percent and 56.9 percent respectively while that of foreign subsidiaries was 99.2 percent. Linsu Kim et al., 281.

180. For an explanation of the zero sum nature of domestic rivalry see Chapter Three under the heading of 'Globalization.'

181. Kilnam Chung, 149.

182. Howell, 150

183. Ibid., 152

184. The export orientation of the electronics chaebol may have been a factor in making possible inter-firm cooperation. As noted earlier, due to their export orientation the Korean chaebol are not engaged in a zero sum game of rivalry for domestic market share as is the Brazilian industry. Thus they would be more likely to cooperate with one another as this would increase their chances of success in the world market where one firms gain of market share would not significantly offset anothers.

185. Howell, 150.

186. Located in Santa Clara, California, Tristar manufactured 64K Drams under license from Micron Devices, of Boise, Idaho. Electronics Week, 19 April, 1984, 105.

187. For example, according to an AT&T executive who serves as chief officer of a Goldstar-AT&T joint venture "we meet each others needs. Goldstar is solving our objective of lowering production costs and building capacity and we are meeting their objective of foreign marketing and broadening their product base. Chung, 170.

188. Howell, 162-3.

189. Mark Clifford, "New Kids on the Block: Dumping Suit Puts South Korean Semiconductor Makers on the Defensive," Far Eastern Economic Review, 7 May, 1992, 60.

190. Ibid., 61.

191. Kim et al., 288.

192. Ibid., 283.

193. Unlike its Korean counterparts which at the time preferred to manufacture computers for U.S. companies through the OEM mechanism Hyundai's electronics division was established in 1983 with the express purpose of developing and marketing its own products by initially resorting to its parent company's car dealership network in the U.S. as its marketing body. However, Hyundai Electronic's IBM compatible model failed miserably; barely achieving one-tenth of the 250,000 sales target. Due to mounting losses Hyundai abandoned the plan and was compelled to close its semiconductor operations in silicon valley. The venture's failure was largely the result of its products low price performance ratio. The failure was not surprising given the Korean computer industry's low technological capabilities at the time and the lack of a recognizable brand name. In the late 1980s, however, with the possession of greater technological capabilities and a recognizable brand name, associated with the company's reputable automotive division, Hyundai Electronics made another stab at marketing its own product which has met with some success thus far. Far Eastern Economic Review, 18 June, 1987, 90-91.

194. For Example, Samsung, the largest Korean electronics company was making computers for Novell Inc. of Provo Utah. When Novell got out of hardware, Samsung took the entire hardware group and set it up as Samsung Data Systems. It now pushes a full line of PC products. Another electronics giant, Daewoo was a manufacturer for Leading Edge Computers of Westborough, Mass. When Leading Edge went under Daewoo bought it. Since the acquisition, in January 1990, sales have jumped from 1,000 to 5,000 PCs a month in November 1990. "Making Their Brand Names," The Globe and Mail, 26 November 1990, B1, B2.

195. Ibid.

196. "Entering the High Stakes, Brand Name Game," Business Korea, Vol.8, Iss.9, March 1991, 54-56.

197. Ernst and O'Connor, 26. and "Bush delivers unfair trade warning," The Financial Post, February 28, 1989, 8.

198. In the late 1980s the U.S. targeted Korea as a potential unfair trading nation under the Omnibus Trade Bill and has applied strong pressure on Seoul to further reevaluate its currency and allow more imports. "Bush Delivers Unfair Trade Warning," The Financial Post, 28 February 1989, 8.

199. Examples include Tristar, Samsung's American semiconductor affiliate. Tristar began production of 64K DRAMs in 1984 and 256K DRAM production in 1985. Richard Langlois et al., 82.

200. The Globe and Mail, 26 March, 1992, A9.

201. "South Korea," South Survey, September 1988, 77.

202. According to the Financial Post Lucky Goldstar will set up an electronics factory and an office complex in the Soviet Union through a US \$380

million joint venture with a Soviet company and the U.S. firm Bechtel. Financial Post, June 14, 1988, p.8.

203. The eagerness of Japanese firms to source Korean components stems largely from two factors. First, Japanese producers need to cut their needs to make commodity chips in highly capital intensive business thus freeing resources that can be channeled to the design and manufacture of products on the frontier of the technological landscape. Second, this would help Japan to meet one of the most controversial provisions of the semiconductor accord signed with Washington in 1986, under which Japan is required to increase the foreign share of its chip market to 20 percent by the end of 1992.

204. "In the 1980s, the Dram market was a linear march from one generation to the next. Computer makers were hungry for all the power and memory that they could find. There was a smooth transition from the 16K chips that powered the first personal computers a decade ago to the 64k chips and then on to the 256K chips, with demand surging as prices fell. But this silicon cycle has changed. One generation no longer simply follows another. Demand for the four-megabit DRAM has been slower to take off than chip makers had expected, even though prices have dropped sharply. That will stretch the (product) cycle, ultimately benefitting late entrants such as the South Korean companies. In addition, Japanese electronics companies, which are being crimped by falling earnings and rising capital costs, are cutting back DRAM capacity and putting some investment on hold." Clifford, "New Kids on the Block...," 61.

205. Mark Clifford, "Breakneck Expansion: South Korea's Booming electronics Industry Still Relies on Imports," Far Eastern Economic Review, 7 January, 1988, pp.42-3. At the same time the high value of the yen has enabled Korean producers to cut into the Japanese share of the market.

206. In 1986 components and parts amounted to 70 percent of the \$4.5 billion in electronics products imported. East Asian Executive Reports, Vol.10, Iss:10, 15 October, 1988, 21-24.

207. Liepziger, 194.

208. For instance, each DRAM generation has cost \$50 million more to develop and manufacture than the one before. Total costs for the 4 Mbit Dram are likely to reach US\$ 2 billion for each company and US\$ 5 billion seems a reasonable estimate for the 64 Mbit DRAM. Clive Cookson, "New Generation Memory Chips on Drawing Board," The Financial Post 17/19 February 1990, 44.

CHAPTER SIX

Conclusion

The 'Heartland' nature of microelectronics technology has bestowed upon it such importance that all nations, developing and developed alike, aspire to understand its benefits and to formulate policies to achieve them. The ability of nations to do so varies in accordance with the policy tools employed. The efficacy of these in turn must be judged against international standards due to the globally pervasive nature of the technology and, thus, the industry.

The case studies of Brazil and Korea have presented us with two such attempts. In this chapter the experience of the two is summarized with a view to understanding the reasons for and efficacy of the strategies employed by each nation and the lessons that can be drawn for other developing nations with similar ambitions in microelectronics.

The different patterns of state intervention adopted by Korea and Brazil in the process of developing microelectronics capabilities are representative of two competing industrial and trade regimes. That pursued by Korea is outward oriented and based on the idea of full integration into the world economy. By contrast, that pursued by Brazil is inward oriented. While it may espouse the benefits of participating in the international economy this is constrained by a strong undercurrent of economic autarchy which stresses the need for autonomy, often at the expense of efficiency and competitive ability, in the process of industrial development.

The divergence in the strategies pursued by the two nations stems from historical circumstances, differences in market size and natural resource endowment in addition to differences concerning the costs and benefits of integration into the global economy.

Despite Korea's relatively high level of GNP per capita it remains a small country, in terms of population, in comparison to Brazil. Additionally, it is extremely poorly endowed as far as natural resources are concerned. Consequently, Korea has targeted exports as a crucial means in financing its import requirements and achieving scale economies in industries such as microelectronics.

Brazil on the other hand is a vast country possessing a *potentially* vast domestic market and rich in natural resources. Consequently it does not need to rely on exports to the extent that Korea does to meet its resource requirements and has attempted to industrialize on the basis of internal demand.

The choice of industrial strategy has also been greatly affected by each nation's conception of the costs and benefits of integrating into the global economy and its upshot, the international division of labour. Korea has viewed integration into the global economy as beneficial. It has not viewed the international division of labour as a given rigid structure but rather as a changing process, shaped by the interaction of national policies, through which it can effectively achieve its industrialization objectives.

Brazil on the other hand has viewed full integration into the global economy with apprehension. It has tended to view the global division of labour more as a structural constraint that could undermine the ability of the state to steer the process of industrialization and hence by extension its ability to safeguard the nations security. These concerns have in turn been bolstered by

Brazil's aspirations of becoming a regional power.

In both cases the state has played a prominent role. The pattern of state intervention, however, has differed considerably in accordance with the choice of industrial strategy. In the case of Brazil, industry is seen as a constituent part of the national strengthening process and in this respect Brazil's disposition is indistinguishable from that which prevailed in the former socialist bloc countries.

Within the context of its import substitution strategy, industrial development has proceeded almost always on the basis of import demand which is then substituted by domestic production. If a particular industry happens to be of marked importance to national security then it is given higher priority and pushed on an expanded scale. Considerations relating to existing production and technological capabilities are given scant attention as are considerations relating to market size. This is so as the strategy pursued is one of backward building and not based on the basis of existing capabilities.

As we have seen, the development of the informatics industry is typical of this scenario. The industry was initially targeted for development on the basis of the high volume of informatics imports and the sectors importance to national security. With little to no domestic production and technological capabilities the industry was begun by building backward on the basis of import demand and the military's needs. Little attention was given to domestic conditions and market structure. As a result, when the government licensed numerous new companies to manufacture informatics products and allowed the unrestricted entry of firms into the microcomputer market the result was a fragmented market structure inhibiting scale economies and efficient production. Those in charge of the industry's development appeared to be blind to the size limitations

with scant attention to domestic capabilities, which were lacking. Domestic producers were unable to keep up with demand and consequently the industry's growth was impeded.

While Brazil managed to develop in-depth capabilities in some areas the rapid pace of technological change made these capabilities obsolete from a competitive standpoint. The industry's competitive shortcomings are reflected in its poor performance in the domestic and export markets. As was shown in Chapter Five, in the former case the industry has developed customers almost exclusively in the banking sector and as for exports, they are negligibly low and oriented to markets less sophisticated than the domestic market. Thus, Brazilian producers, as was shown, failed to garner either the static or dynamic efficiencies associated with demand.

By contrast, in Korea, the tendency has been to target industries for development on the basis of existing capabilities, that is, on the basis of forward building. The informatics industry was begun on the basis of existing capabilities in the electronics sector, particularly consumer electronics, and the country's relatively large stock of skilled human capital. The development of the microelectronics industry was a case of technological extension, motivated not by national security concerns per se, but by changing domestic and international economic parameters which required the restructuring of the electronics industry on a higher level of technological intensity to maintain and improve the nation's competitive advantage in the global economy.

While Korea has not ignored the development of in-depth capabilities, its first and foremost concern has been to develop a globally competitive industry. To this end it adopted a progressive stance towards technology transfer, pushed globalization and emphasized the need for heeding end user requirements.

Additionally, recognizing the size limitations of the domestic market the industry was at first geared to export markets to enable the development of scale economies which in turn speeded up the learning process. Moreover, the industries' structure, comprised of a few large vertically integrated oligopolistic firms, was in congruence not only with the size of the domestic market, thus avoiding market fragmentation, but more importantly with the Schumpeterian evolution of the industry discussed in Chapter Two.

Thus it was able to make headway into the markets of the OECD countries and established itself as one of the principal players in the global microelectronics industry.

Judging from the experience of the two nations the fundamental conclusion to be drawn is that technological nationalism can be poison to the development of global high tech industries such as microelectronics, particularly so for developing countries such as Brazil and Korea. Developing countries have neither the capital resources nor the vigorous domestic markets to make strategies emphasizing self-sufficiency approaches a viable concern. True, Brazil's strategy can by no means be categorized as a failure; relative to some other developing countries it has made substantial progress. But at what cost? Such strategies carry with them an expensive price tag which is reflected in the "heavy charges laid at the door of the national treasury as well as the extra costs concomitant with less than optimum production efficiencies. These inefficiencies, in turn, constitute an inescapable burden on consumption which has to be borne by the local population."²⁰⁹ Fortunately, the Brazilian state has managed to explain much of this away as being essential to national development not to mention the defense preparedness of the state.

Given the globally pervasive nature of the technology, Brazil's experience

cannot be judged on a national basis but must be judged on an international basis. On this basis, as we have shown, the industry is clearly uncompetitive, lacking efficient production levels and lagging several generations behind state of the art technology.

This is not to say that Korea's experience has been free of afflictions. The rise of technological and trade protectionism in its major export markets have revealed the inadequacy of its capabilities in component design for an industry that is in competition with major global players and its overdependence on the American and to a lesser extent the European market for export demand. These are major problems but they pale in comparison to those of the Brazilian industry. The Korean industry appears to possess both the resources and the commitment to overcome its problems; as was shown it has already made some headway in doing so, as exemplified by its growing trade with China. The future of Brazil's industry on the other hand is much more uncertain. Stripped so suddenly of the highly protective environment in which it has been nourished for so many years without the opportunity to undertake the requisite restructuring imperative to making it a globally competitive industry its future prospects seem highly precarious, at least from the standpoint of possessing the requisite resources to increasingly regenerate itself based on its own resources.

True, this work presents the most laconic view of the experiences of Korea and Brazil and the nature of competition in the microelectronics industry. A comprehensive view would have to include a study of other major sectors in the microelectronics complex, notably telecommunications and software; such a study, however, would comprise a volume in itself and is therefore beyond the compass of this paper. But, it is hoped, this reading has managed to capture the gist of the different patterns of state intervention exercised by Korea and Brazil

in regard to the microelectronics industry and how they measure up to the competitive demands of the industry as dictated by the pace and nature of technological change occurring globally.

NOTES (Chapter Six)

209. Daniel Todd, 291.

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