OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

No. 21

In this issue

1 **The integrated circuit industries of India and the Republic of Korea in an international techno-economic context**
Charles Edquist and Staffan Jacobsson

63 **Employment linkages in Bangladesh industries**
Dilip Kumar Roy

75 **Some comments on estimating national economic parameters for Jamaica**
John Weiss

99 **Developing local industry through centres for industrial studies in tertiary institutions in developing countries**
Peter B. U. Achi

111/113 **Sommaire—Extracto**

UNIDO

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

INDUSTRY AND DEVELOPMENT

No. 21

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna, 1987

AIMS AND SCOPE OF *INDUSTRY AND DEVELOPMENT*

Industry and Development attempts to provide a link between practitioners and theorists working on economic and related aspects of industrialization. The focus of the journal is on applied economics, particularly in areas emphasized in the Lima Declaration and Plan of Action on Industrial Development and Co-operation.

The journal is published an average of four times a year as an integral part of the work programme of the Studies and Research Division of the United Nations Industrial Development Organization. It is prepared under the general guidance of a Supervisory Panel, composed of staff members from the Division, with the Head of the Global Studies Branch as its chairman. Responsibility for the detailed supervision of a specific issue is rotated among the members of the Panel. The responsible member for this issue was J. Cody.

The Supervisory Panel of *Industry and Development* welcomes readers' opinions and comments, and will be glad to consider for possible publication articles relevant to the aims and scope of the journal (see "Information for contributors", back cover).

ID/SER.M/21

UNIDO PUBLICATION
Sales No.: E.87.II.B.1
ISBN 92-1-106220-9
ISSN 0250-7935
01500P

Explanatory notes

The term "billion" signifies a thousand million.

References to dollars ($) are to United States dollars, unless otherwise stated.

The monetary unit in India is the rupee (Rs).

A slash (/) between dates indicates a financial year.

In tables:

Totals may not add precisely because of rounding.
Two dots indicate that data are not available or are not separately listed.
A dash (--) indicates that the amount is nil or negligible.

The following abbreviations are used in this publication:

Organizations

BEL	Bharat Electronics Ltd.
CIS	Centre for Industrial Studies
ECIL	Electronics Corporation of India Ltd.
GSS	Gold Star Semiconductor Ltd.
IADB	Inter-American Development Bank
IDC	Industrial Development Centre
ITI	Indian Telephone Industries
KIET	Korea Institute of Electronics Technology
OECD	Organisation for Economic Co-operation and Development
SCL	Semiconductor Complex Ltd.
SST	Samsung Semiconductor and Telecommunications Co. Ltd.

Technical abbreviations

ASIC	application-specific integrated circuit
BL	backward linkage
CAD	computer-aided design
c.i.f.	cost, insurance, freight
CMOS	complementary metal oxide semiconductor
DRAM	dynamic random access memory
FL	forward linkage
GNP	gross national product
IC	integrated circuit
K	kilobit
LSI	large-scale integrated
MOS	metal oxide semiconductor
MSI	medium-scale integration
NMOS	n-channel metal oxide semiconductor
RAM	random access memory
ROM	read-only memory
SRAM	static random access memory
SSI	small-scale integration
VLSI	very large-scale integrated

THE INTEGRATED CIRCUIT INDUSTRIES OF INDIA AND THE REPUBLIC OF KOEEA IN AN INTERNATIONAL TECHNO-ECONOMIC CONTEXT

Charles Edquist and Staffan Jacobsson*

Introduction**

Considerable attention is given, in the literature and in media, to the electronics industry in developed countries. Of all branches of this industry, it is the core, the integrated circuits, which has commanded the greatest interest. Firms and Governments often regard this industry as strategically essenticl, a view which has also found support in some developing countries.

In this paper an anlysis of the integrated circuits industries of India and the Republic of Korea is presented. These two countries were chosen for field work since they have followed very different industrialization strategies. Section A contains a description of what integrated circuits are, and section B provides an overview of the international industry producing them. The objective of section B is to outline the international techno-economic context for the integrated circuits industries of India and the Republic of Korea, and thereby to present the existing knowledge in a new light. The industries of the Republic of Korea and India are surveyed in sections C and D respectively. Finally, in section E the approaches of the two industries within the international techno-economic context are compared. Some determinants of their diverging approaches are also discussed.

---

*Both authors were at the Research Policy Institute, University of Lund, Sweden, when this article was written. Since then both have taken up positions at other universities. S. Jacobsson has a research post in the Department of Industrial Organisation, Chalmers University of Technology, S-41296, Gothenburgh, Sweden. C. Edquist is professor in the Department of Technology and Social Change, University of Lintröping, S-581 83, Lintröping, Sweden.

**This paper was prepared within the framework of a project on technical change and patterns of specialization in the capital goods industries of India and the Republic of Korea. The project was financed by the Swedish Agency for Research Cooperation with Developing Countries, the support of which is gratefully acknowledged. Grateful thanks are also due to the National Council for Applied Economic Research, New Delhi, and to the Korean Institute for Economics and Technology, Seoul, for help during field work. Finally, A. Parthasarathi, Additional Secretary of the Ministry of Science and Technology of India, went through a draft in great detail. His extensive comments were extremely valuable. For other work undertaken within the framework of the project, see Edquist and Jacobsson ([7]-[14] and [46]).

A. The product

Semiconductors are manufactured from materials that have semiconducting properties, mainly silicon. They consist of transistors and other components which can amplify, switch or modulate an electrical input signal in a circuit. Semiconductors can be divided into the following three groups: discrete components (such as transistors, rectifiers and diodes), integrated circuits (ICs) and special-purpose components. The IC (chip) is a small piece of semiconducting material. It is the reduction in the size of the chip and the increase in the number of its circuits that has led to the use of the term micro-electronics. ICs are the largest and fastest-growing product group in the semiconductor industry, and the relative importance of discrete components is decreasing. The first integrated circuits were marketed in 1962 ([47], p. 16).

ICs may be classified as bipolar or metal oxide semiconductors (MOS), according to the technology used in their manufacture. The relative importance of the processes and their subgroups are reflected in figure I.

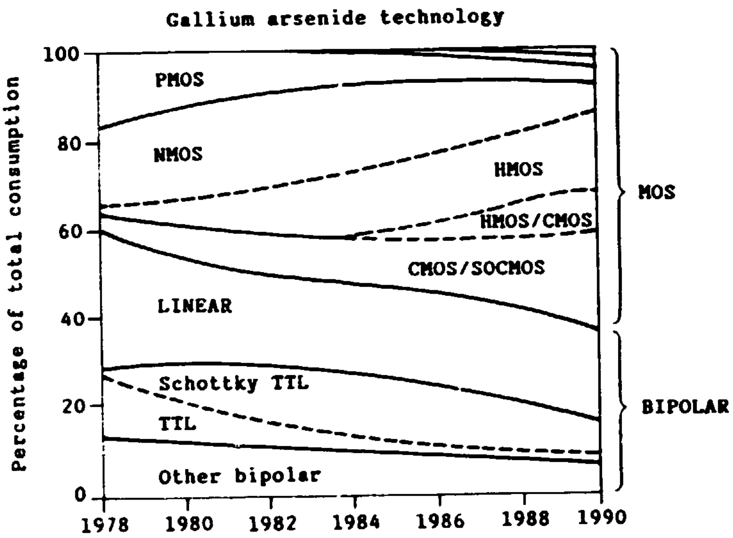
By 1990 MOS technology is expected to constitute approximately 63 per cent of the total market for ICs. Within the MOS industry, the 1980s will continue to witness a move toward complementary metal oxide semiconductor (CMOS) technology. CMOS is gaining momentum in most products with very large-scale integrated circuits thanks to its low power consumption (meaning a low volume of waste heat). CMOS will probably also dominate the production of application-specific (custom-designed) ICs in the future ([41], pp. 92-95).

A further classification can be made according to the scale of integration on a chip, that is, the number of circuits or transistors that it has (see figure II).

A final classification is based on the function of the semiconductor device, that is, linear devices and digital devices. Linear devices convert input signals to output signals. They are used in telephones, radio and television receivers and analog equipment. Digital devices use the on-off switching properties of transistors and diodes. They include logic devices, microprocessors, memory devices and special devices. Digital devices form the basis of modern computing and telecommunications technology. ([33], p. 7).

Two main types of ICs are microprocessors and memories. Microprocessors are circuits which inlcude all the functions contained in the processing unit of a computer on one single chip. Memories are circuits which store information. There are two memory groups, namely random-access memories and read-only memories. Read-only memories (ROMs) are memories the contents of which can be read but not modified. Individual locations can be addressed in an arbitrary order in random-access memories (RAMs). Their capacity is measured in terms of binary digits (bits) of data

Figure I. World consumption of integrated circuits by process technology



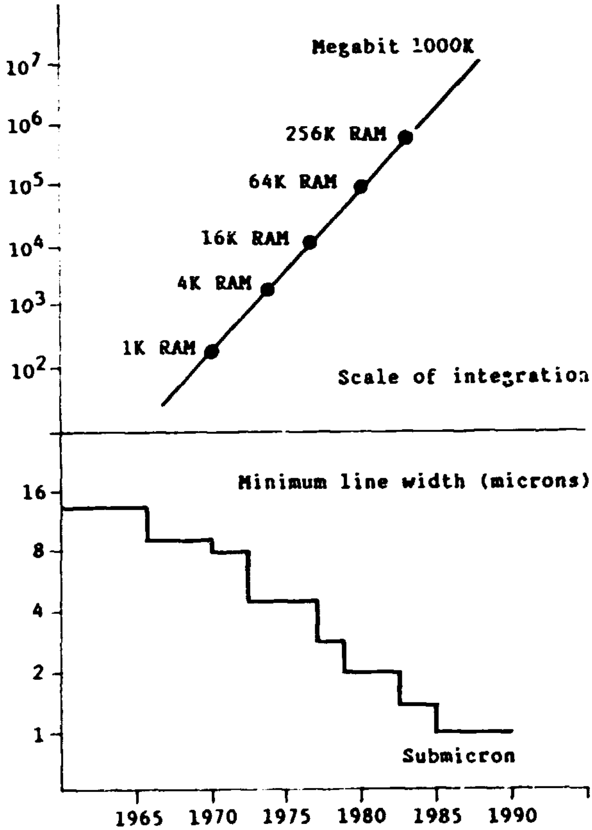
Source: [41], p. 92.

Notes: CMOS: complementary metal oxide semiconductor
HMOS: Hybrid metal oxide semiconductor
NMOS: n-channel metal oxide semiconductor
PMOS: p-channel metal oxide semiconductor
SOCMOS:
TTL: transistor-transistor logic

Source: [41], p. 92.

Notes: CMOS: complementary metal oxide semiconductor
HMOS: hybrid metal oxide semiconductor
NMOS: n-channel metal oxide semiconductor
PMOS: p-channel metal oxide semiconductor
SOCMOS: selective-oxidation CMOS
TTL: transistor-transistor logic

Figure II. Scale of integration and minimum line width of dynamic random access memories



K = one thousand bits

Source: [47], p. 19.

storage. The first 16-bit RAM was introduced in 1966. The RAM bit density has quadrupled every two to three years since then. The first kilobit (1 K or 1,024 bits) RAM was introduced in 1974. At present (mid-1986), 256 K RAMs have started to be produced commercially, and the one megabit RAM is expected to be produced commercially in the near future. According to the Financial Times [2], the 1,000 K dynamic random-access memory (DRAM) chip will "hit the market this year". Figure II shows the evolution of the scale of integration of DRAM circuits (16 K, 64 K etc.) and their minimum line width in microns. The miniaturization means that an increasing number of transistors are integrated on a single chip. Small-scale integration (SSI) means 30 to 80 transistors per chip, and very large-scale integration means 30,000 to 100,000 transistors per chip. Medium-scale integration (MSI) and large-scale integration (LSI) come in between ([47], p. 16).

Microprocessors and memories are standard ICs, often produced in huge volumes and sold in bulk. Application-specific integrated circuits (ASICs) are specifically designed for a particular application or a particular customer.

As shown in figure I, ICs can be produced by means of several processes. There is also more than one way of designing them, as described below:

(a) Handcrafted design means that the whole circuit is manually drawn on a computer-aided design (CAD) system from scratch. This is a very expensive way of designing and can therefore only be used for circuits which are to be produced in very large quantitites, that is, standard circuits and ASICs used in watches and calculators;

(b) Gate array design means that one starts from semi-manufactured chips and achieves the desired function by designing a pattern of connections between the various standard gates or cells already on the chip. Hence the semi-manufactured chip is customized through a final metallization. This is a cheap way of designing ICs, but also rather inflexible. In addition, the chips often become large. This design method is therefore mainly used for prototypes and for ICs to be produced in very small quantitites;

(c) Cell-based or standard cell design means that a library of already designed cells are stored in the computer and then connected. The connection takes place in the computer, that is, before any chip processing is done. Hence this design method is similar to gate array design, except that it is not necessary to use semi-manufactured chips. Thereby full flexibility is achieved.

B. The global IC industry

The main objective of this paper is to describe and analyse, in a preliminary manner, the production of integrated circuits in India and the Republic of Korea. However, in order to be able to do this, it is essential first to describe the international market for ICs and the barriers to entry into the international industry. Thus, in the assessment of the IC industries of India and the Republic of Korea, the international industry will be taken as the point of reference.

1. The market for integrated circuits

Total world consumption of semiconductors was estimated at a value of approximately $18.5 billion in 1983. Of this, the United States of America had the largest share (54 per cent), followed by Japan (26 per cent) and Western Europe (16 per cent), leaving 4 per cent to the rest of the world ([33], p. 12). As shown in figure III, ICs account for over 80 per cent of semiconductor shipments to consumers in the United States. For Western Europe and Japan, the ratio of ICs in such shipments is around 66 per cent (see figures IV and V) with discrete semiconductors playing a much more important role. The substantial consumption of discrete devices in Japan and Western Europe reflects the relative importance of the consumer electronics industry in those countries as compared with the strength of the data-processing industry in the United States, where ICs are mainly required (see table 1).

As shown in table 1, the computer market dominates the global sales of ICs, the recent surge in demand for which is mainly due to the growth in the demand for microcomputers and personal computers.

Table 1. Value of the IC market by end-use, 1982
(millions of dollars) a/

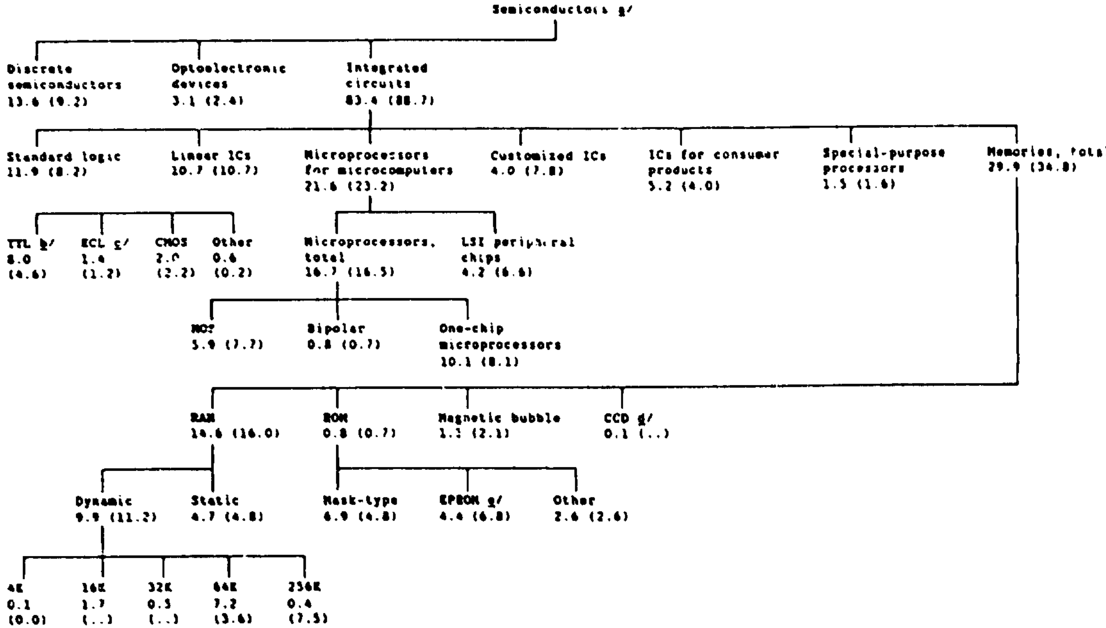
End-use	IC market value: All OECD b/ countries	United States	Japan	Western Europe
Computers	3 736 (32)	2 914 (40)	336 (13)	486 (25)
Telecommunications	2 176 (18)	1 523 (21)	261 (10)	392 (20)
Office automation and other industrial uses	1 970 (17)	808 (11)	670 (26)	492 (25)
Consumer products	2 614 (22)	810 (11)	1 307 (51)	497 (25)
Government and military uses	1 340 (11)	1 233 (17)	0 (0)	107 (5)
Total	11 836	7 288	2 574	1 974

Source: Table 1 in Ypsilanti ([47], p. 15).

a/ Figures within parentheses represent percentage of market.

b/ Organisation for Economic Co-operation and Development.

Figure III. Semiconductor supplies to consumers in the United States: 1983 distribution and 1987 forecasts



Source: [33], p. 13, based on Electronics, 12 January 1984.

Notes: Data based on market estimates of industry consumption of goods supplied by United States and foreign manufacturers to the United States market.

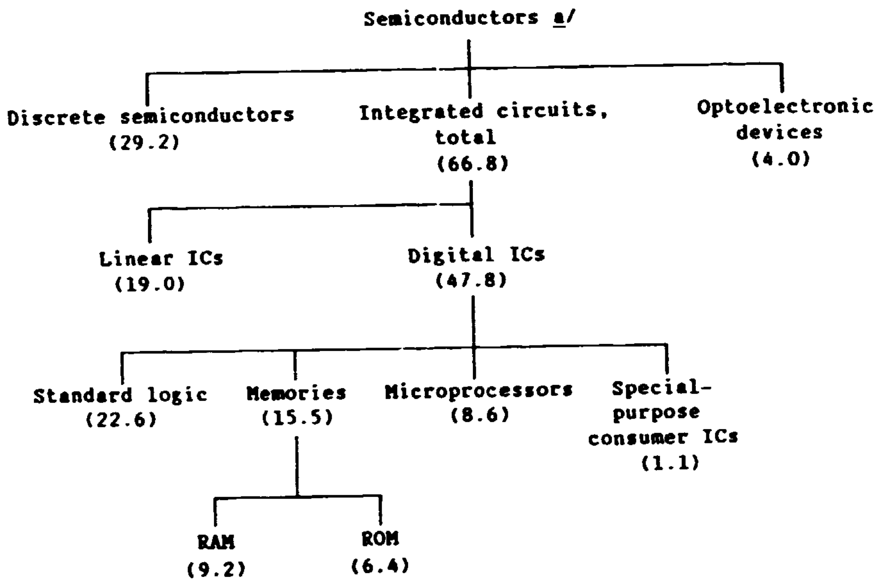
Figures represent percentages of total.

Figures without parentheses are for 1983, those within are 1987 forecasts.

Totals may not add precisely because of rounding.

a/ Total value in 1983 - $10.1 billion; forecast for 1987 - $19.4 billion.
b/ Transistor-transistor logic.
c/ Emitter-coupled logic.
d/ Charge-coupled device.
e/ Erasable programmable read-only memory.

Figure IV. Semiconductor supplies to consumers in Western Europe, 1983



Source: [33], p. 14, based on Electronics, 12 January 1984.

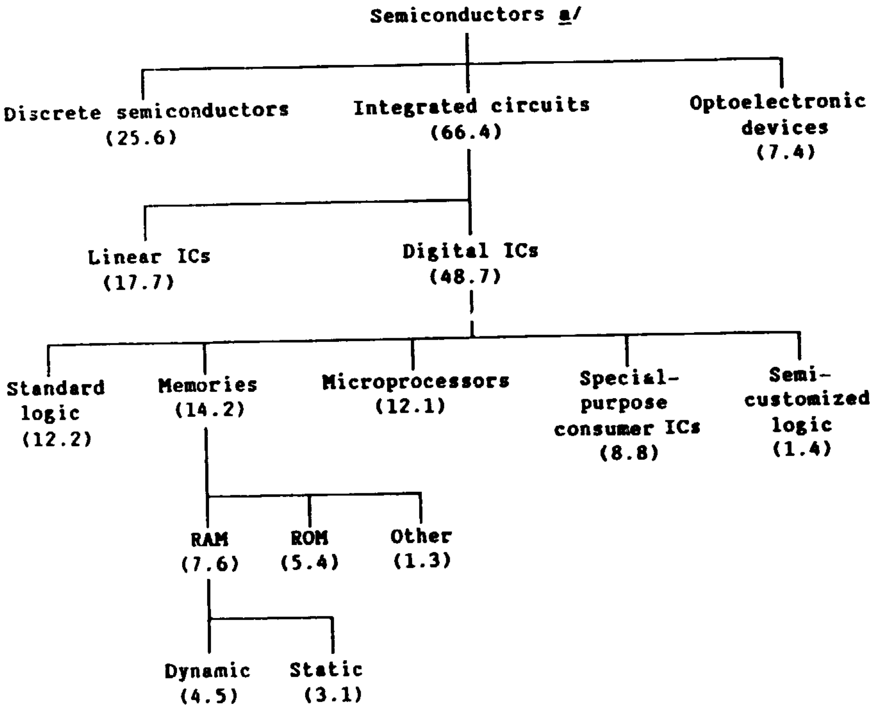
Notes: Data based on market estimates of industry consumption of goods supplied by domestic and foreign manufacturers to the domestic markets.

Figures within parentheses represent percentages of total.

Totals may not add precisely because of rounding.

a/ Total value in 1983 - $2.9 billion.

Figure V. Semiconductor shipments to consumers in Japan, 1983



Source: [33], p. 14, based on Electronics, 12 January 1984.

Notes: Data based on market estimates of industry consumption of goods supplied by domestic and foreign manufacturers to the domestic market.

Figures within parentheses represent percentages of total.

Totals may not add precisely because of rounding.

a/ Total value in 1983 - $4.9 billion.

In the United States 40 per cent of the ICs were, in 1982, used in computers, while 11 per cent went into consumer products (see table 1). In contrast to the United States, the driving force behind the IC industry in Japan has been consumer electronic products. By 1982, this branch of industry accounted for 51 per cent of end-use consumption of ICs made in Japan. The figure for computers was only 13 per cent. In Western Europe, the end-use has been more evenly distributed across the major industries. There are also differences in the absolute size of the markets mentioned. For example, in 1982, the use of ICs by the United States computer industry alone was larger than the use of ICs for all purposes in Japan and nearly one and a half times larger than in Western Europe.

The more important and growing product categories in semiconductor consumption include memories (in particular RAMs), custom-made devices and microprocessors. In the United States, memories accounted for 30 per cent of semiconductor supplies in 1983 (see figure III), compared with 15 per cent and 14 per cent respectively for Western Europe (see figure IV) and Japan (see figure V). For the United States, the growth in memory device consumption between 1983 and 1987 is expected to account for over a third of the growth in IC consumption over the same period ([33], p. 12; [47], p. 16). Within the DRAM category, the 64K circuit dominated heavily in 1983 (see figure III). By 1987, 256K are expected to account for almost 70 per cent of the DRAM market. By that time, the demand for 4K, 16K and 32K DRAMs is expected to be negligible, and the market share for 64K will be only 32 per cent, as compared with 73 per cent in 1983.

For most ICs there have been large price reductions over time. For example, the drop in unit price of 64K DRAMs has been considerable since 1979. In 1980, experts expected prices to stabilize around $50 per unit. However, they actually fell to $10 in 1981-1982. By the end of 1982, prices were between $3.50 and $5 ([47], p. 20). At the end of 1984, the price was $3.00, but it fell to as little as $0.5 in the middle of 1985 [2]. A similar story can be told for 256K DRAM, the prices of which have already been reduced from $20 to $5 ([6], p. 12).

Custom and semi-custom-designed ICs or ASICs are the fastest-growing items, although there seems to be no uniformity in the estimates regarding either their present or their future share of the global consumption of ICs. According to one source ([44], p. 34), the total global market for ASICs should grow from $3.8 billion in 1983 to $13.7 billion in 1989, that is, at a 24 per cent compound annual growth rate. According to figure III, custom ICs accounted for 4.0 per cent ($404 million) of all semiconductor supplies in the United States in 1983. This figure is expected to increase to 7.8 per cent ($1,513 million) by 1987.

According to an interview with a Swedish firm specializing in customized ICs, 20 per cent of the IC market is made up of custom-designed ICs, and this figure is expected to increase dramatically.

A representative of the firm also indicated that the market for standard ICs will remain constant and be characterized by tougher competition resulting in fewer and larger producers.

Although the figures presented here are partly inconsistent, it seems clear that the proportion of custom-designed ICs will increase substantially in the future. A number of reasons exist for this expansion of the market for custom-designed ICs. A basic advantage for a firm using custom-designed ICs is that it gets an integrated circuit which its competitors do not have access to. In some circumstances this means that the competitive edge of the user of custom-designed ICs, for example a producer of sewing machines or telephones, can be significantly enhanced in terms of both performance of the product which incorporates the custom-designed IC and, sometimes, its cost.

Consumption of microprocessors accounts for 21 per cent of current United States semiconductor supplies, compared with 12 per cent in Japan and 9 per cent in Western Europe ([33], pp. 12-13).

2. Barriers to entry into IC production

(a) Standard integrated circuits

As shown in table 2, the leading manufacturers of integrated circuits produce in large volumes. The minimum investment requirement for IC production (wafer fabrication only) was $500,000 in 1967 (see table 3). By 1978 it had increased to $10 million. The capital requirement for wafer fabrication and assembly was $60 million in 1982. The price for a new large-scale CMOS chip-making plant currently exceeds $100 million, which means that the cost is rapidly approaching that of steel mills. Indeed, the Financial Times [2] suggests that "a typical wafer fabrication plant costs between $100 million and $200 million to build ...". Such a state-of-the-art chip-making plant can offer a full product line for standard ICs, including microprocessors and computer memory chips ([35], pp. 86-87). For company data on capital expenditures during the period 1978-1981, see table 4.

The minimum fixed investment necessary for processing standard ICs has therefore been rising very steeply. The increase in capital requirements is a result of the greater circuit complexity of semiconductor devices, which requires more sophisticated and expensive production and, in particular, testing equipment. Squeezed between rising capital costs and intense competition, many United States firms tried to reduce costs by shifting assembly to South-East Asia. The response of Japanese companies, whose example is being increasingly followed by United States companies ([33], p. 39), was to increase the degree of automation in assembly, thus leading to a further rise in capital costs.

Table 2. Estimated value of standard IC production a/ by leading open market suppliers in the United States and Japan, 1983

Company	Production (millions of dollars)
Texas Instruments	1 445
Motorola	1 040
NEC Corporation	940
National	790
Intel	745
Hitachi	705
AMD	485
Toshiba	480
Fujitsu	470

Source: [41], pp. 33 and 45.

a/ Semi-customized and fully customized IC production is also included wherever joint production is undertaken.

Table 3. Minimum investment requirements for semiconductor (IC) production

Year a/	Investment required (millions of dollars)
1954	0.1
1958	0.3
1967	0.5 b/
1972	2 b/
1976	5 b/
1978	10 b/
1982	60 c/

Source: [33], p. 38, based on J. L. Truel, Professional Press.

a/ By 1985 the cost of a state-of-the-art plant for producing standard ICs was approaching $200 million [2].

b/ Wafer fabrication only.

c/ Total wafer-assembly cost.

Table 4. Semiconductor-related capital expenditures by major United States and Japanese corporations, 1978-1981 (Millions of dollars)

Corporation	Semiconductor-related expenditure 1978	1979	1980	1981
A. United States				
Texas Instruments	130.2	238.5	285	213.8
Motorola	72.1	158.8	176.5	200
Intel	14.2	96.7	152.2	150
Mostek	18.8	75	132	94
NSC	65.4	110.4	151.6	151
Signetics	36	48	93	117
Fairchild	22.9	58	75	120
AMD	23.5	43.9	50.2	100
Harris	14.7	12.5	31.1	60
GI	9.3	30.5	28	50
Average for United States corporations	49.7	87.2	117.4	125.6
B. Japan				
NEC Corporation	67	115	136	162
Hitachi	44	64	98	119
Fujitsu	50	68	115	115
Matsushita	22	43	94	94
Toshiba	26	43	55	64
Oki Electric	15	23	57	60
Mitsubishi	26	34	43	55
Sony a/			55	45.1
Tokyo Sanyo	7	18	36	51
Sharp	9	37	41	43
Average for Japanese corporations	29.6	46.6	70.9	81.8

Source: [43], p. 262.

a/ Captive producer; capital expenditures calculated as percentage of semiconductor production value.

In addition to increasing capital costs, the costs of research and development have increased in both absolute and relative terms. Firms trying to follow a "leading-edge" strategy have been forced to increase their research and development expenditures, partly owing to the increased international competition which started in the mid-1970s ([33], pp. 38-40). One part of research and development costs covers the actual design work on the ICs.

For standard ICs the design mode used is handcrafted design, which is very expensive (see section A). Several hundred man-years - which may mean $5-10 million - are needed to design one single microprocessor or advanced memory chip. Full-range IC suppliers, such as Motorola and Texas Instruments, spent, respectively, $229 million and $219 million on research and development in 1981, while Intel spent $167 million ([43], p. 279).

An important consequence of increased capital requirements and increased research and development costs is that the minimum efficient scale of production in the standard IC industry has increased considerably. In the early years of the IC industry, scale was not very important, but it has now become an important barrier to entry. The increase in the minimum scale of production also probably implies that larger companies will play an even greater role in the industry in the future. It will be more difficult for new firms to establish production of standard ICs in countries of the Organisation for Economic Co-operation and Development (OECD) and in selected developing countries. It may also imply that smaller firms may tend towards the production of customized products to a greater extent ([33], p. 39).

As mentioned above, increases in capital costs, research and development costs and, consequently, in the minimum efficient scale of production have developed into important barriers to entry since the mid-1970s. Other barriers are lack of skilled manpower (especially design engineers), lack of market reputation and inadequate supplier-user links.

Figure VI shows three possible strategies, particularly with regard to research and development, that may be adopted by Governments and IC producers. The leading-edge strategy is followed by the leading producers in the United States and Japan, in particular the firms listed in table 2 ([42], p. 59).

The European industry being a latecomer and not being able to keep abreast with competitors, particularly with regard to research and development, runs the risk of following the lagging-behind strategy. The French industry has tried to leave the lagging-behind position through joint ventures with and technology transfers from firms at the leading-edge. This attempt has so far not been successful. It should be pointed out however that the wait-and-see strategy also requires considerable technological know-how, since the leading-edge technology cannot otherwise be used ([42], p. 59).

The IC industry of the Federal Republic of Germany is located on the second line, but there is a danger that it may deteriorate to a lagging-behind position. This has resulted in an effort by the Government of the Federal Republic of Germany and especially of Siemens to undertake large investments so as at least to retain the capacity to adopt the latest available technology. In some fields, especially that of memory chips, it has tried to adopt a leading-edge strategy and thereby reach the technology front. This high-risk strategy resembles that of Japan. The IC industry in the

United Kingdom of Great Britain and Northern Ireland is in a lagging-behind position, although there has been some attempt to transfer to the leading-edge strategy through the Inmos experiment, in which the Government, at a cost of $100 million, established a plant for the production of very large-scale integrated (VLSI) circuits ([42], p. 59).

An important characteristic of the IC industry is the close linkage that exists between process and product innovations in the IC industry proper and between product innovations in this industry and innovations in end-use industries. There is a synergistic relationship between part of the IC industry and some user industries, for example computers and telecommunications. This relationship provides the basis for a great deal of government incentives to foster a local IC industry, as in the United Kingdom with Inmos. This matter will be briefly touched upon in later sections concerning India and the Republic of Korea.

(b) Application-specific integrated circuits

According to yet another source ([34], p. 131), ASICs currently account for less than 16 per cent of global IC consumption. By the end of the 1980s, it is expected to have risen to more than 23 per cent ([34], p. 131). The barriers to entry are much lower than for standard ICs. This will be shown by two examples below. It is also indicated by the fact that 50 per cent of global semiconductor start-ups since 1977 are firms offering some kind of ASIC ([34], p. 132). The giant firms specializing in standard ICs, for example those listed in table 2, also produce ASICs. However, they tend to do so mainly during periods of excess capacity, that is, when the demand for standard ICs is low. Hence the large producers have no genuine interest in specialized low-volume IC production. This presents an element of uncertainty for ASIC customers, who therefore normally prefer the specialized ASIC producers.

The examples of Rifa and ASEA-HAFO, two Swedish producers of ASICs, may help to illustrate the barriers to entry into ASIC production. Rifa was set up in 1942 by a number of Swedish radio producers for the purpose of securing a supply of components during the war. In 1947 it was bought by Ericsson, the telecommunications producer, and has since then been a fully owned subsidiary of this firm. It produces full custom-designed ICs and hybrid circuits for industry, telecommunications and defence. About 40 per cent of its sales (less in the case of custom-designed ICs), which also include other types of electronic components, are sold to Ericsson. The total sales figure in 1983 was slightly over $130 million, of which goods worth $85 million were sold abroad. Of the $130 million, custom and semi-custom-designed ICs accounted for around $35 million and hybrid circuits for about $14 million. Rifa, according to a spokesperson for the company, is one of the largest European producers of custom-designed ICs. The "Status" report ([41], p. 39) has estimated that the world-wide leader in sales of custom-designed ICs is American Microsystems Inc., which sold non-standard ICs valued at approximately $100 million in 1983. Their total sales amounted to $175 million. These sales can be compared to the total 1983 sales of leading standard IC producers, as was shown in table 2.

Since 1977-1978 Rifa has invested approximately $150 million (using 1981 exchange rates) for the production of custom-designed ICs and is planning to invest another $20 million (using 1983 exchange rates) per year during the next five years. Their minimum line width is 2.5 microns and they are heading towards 1.7 microns. To build the Rifa factory today - that is, in 1986 - would cost approximately $25 million, which is about one eighth of what is needed for a memory factory. Equipment costs would account for nearly a half of the $25 million. This investment figure may be substantial for such a small company but is nevertheless small compared with those shown in table 4 and those of Samsung for DRAM production ($240 million in a five year period - see the discussion of IC-producing firms in section B). Rifa spends between 15 and 20 per cent of its IC sales on research and development, that is, for design and process development. The research and development costs would amount to roughly $6 million, which, again, are very limited in comparison with the major IC suppliers. In the design department, which is the main bottleneck for the firm, they employ 30 people. This number is increasing, but they have problems finding experienced designers.

The company thus concentrates intensively on research and development, invests heavily in relation to its sales, and was at one time actually investing too much to be profitable in the short run. However, by 1985 Rifa was profitable.* This example indicates that the orders of magnitude of the barriers to entry are very much lower than for standard IC products.

This experience is supported by the case of ASEA HAFO, another - very successful - producer of ASICs in Sweden. During 1984, the sales of ASEA-HAFO were approximately $25 million, mostly for custom-designed ICs. HAFO is the most profitable company in the ASEA group of engineering firms.

ASEA-HAFO bought a licence from the Radio Corporation of America (RCA) on the MOS process technology in 1970 and the two firms have had a working relationship since then. To build up their complementary MOS process as a whole today would cost less than $15 million (this is the minimum estimate). Costs for buildings etc. must be added to the equipment cost. Hence total investment would be around $25 million. The minimum line width in this process is 4 microns, which is much larger than what is used by producers of standard ICs (HAFO is currently moving towards 2 microns). However, a line width of 1 micron, although necessary for memories, is not necessary for ASIC producers. Nevertheless, they have so far followed suit, with a few years' time lag.

Apart from the production process, investment in design is also needed. The fixed cost for the most simple equipment for IC design is only about $35,000, that is, the cost of a personal computer and software. A complete and sophisticated up-to-date

---

*Information based on interviews with company spokespersons.

design system would cost approximately $500,000. On this equipment two or three ICs could be designed each year, and the cost would increase in a linear manner if the number were to be increased. More important is that it takes time to build up design capability. The cost for this, in salaries, is estimated to be larger than the fixed design cost.*

All the design modes mentioned in section A can be used for ASICs, although firms tend to specialize in one of them, for example gate arrays or standard cells. In recent years the complexity of ICs has increased, resulting in increased development costs. However, more complex circuits are - with the exception of microprocessors and memories - more specialized, which implies reduced volumes. Hence development costs escalate with growing complexity, while the potential market is reduced. One way out of this would be to transfer IC design to companies where the ICs are used, that is, to the equipment manufacturers.

According to Penn ([34], p. 135) there are, at best, 2,500 experienced IC designers in the world today, although it has been estimated** that there are from 6,000 to 7,000. These numbers should be compared with the several hundred thousand designers of systems and equipment. One way of transferring design work to the equipment and system manufacturers would be to embody the expertise of the chip designer in sophisticated computer aids, a process which is under way at present. One example is a system called MOSart developed by the ASIC producer ASEA-HAFO in Sweden. About 100 man-years have been invested in this system of CAD software specifically developed for IC design of the standard cell character.**

If the design activity is transferred from the IC manufacturer to the IC user, then the manufacturer is reduced to the status of a silicon foundry, which may happen to some of them in the future. On the other hand, the manufacturer has the capability of developing the design tools or CAD software. Hence some of today's IC manufacturers could be transformed into firms specializing in design and the development of design tools, in other words, they may develop into design houses for ASICs or into firms developing user friendly IC design aids. A division of labour may also emerge with regard to design, in the sense that the IC user makes the logic design and the IC producer the final layout.

In this section it has been shown that the barriers to entry for the production of standard ICs have increased rapidly during the last decade. The cost of a state-of-the-art factory is $200 million at present, mainly owing to technical change in IC processing. Research and development costs have also risen.

---

*Information based on interviews with company spokespersons.

**Based on interview with ASEA-HAFO spokesperson.

The barriers to entry for ASIC production are much lower. Design costs are lower in absolute terms, since handcrafted design is not necessary. An ASIC factory may today cost around $25 million, which is only one eighth of the cost of a factory for standard ICs. There are several reasons for this. First, an ASIC factory can operate on a much smaller scale since the market is not so price sensitive for specialized circuits needed in smaller volumes. Secondly, automatic assembly is not necessary (however, Rifa is currently investing in an assembly line). Thirdly, and most importantly ASIC producers do not necessarily have to use line widths as low as those of producers of standard ICs. For example, Rifa produces an IC for telephones - called the SLIC - which is at the technology frontier in its field of application. This circuit has a line width of 4-5 microns. On the other hand, a producer of memories simply has to use a line width of around 1 micron at present, and will have to decrease this in future. This means that photolithographic methods are no longer enough, and that X-ray and other methods are becoming mandatory. This, in turn, probably means another jump in process equipment costs.

Since ASIC producers do not have to be at the forefront in terms of line width, there is room for the operations of smaller producers. However, it has been indicated that the ASIC producers have generally adopted the most advanced technology, with respect to line width, with a few years' time lag. This means that process equipment costs will also probably increase for ASIC producers, but it will not increase to the same extent as for standard IC producers. The reasons are that the equipment becomes cheaper over time and that ASIC producers can operate on a smaller scale. Whether or not ASIC producers will have to adopt submicron line widths in the long run is unclear (this would mean a jump in the process equipment costs, as mentioned above). However, it is unlikely to become necessary during the next five years. Hence small ASIC producers will conti[illegible] to have a role to play for some time at least.

From this section it is clear that the IC industry can be divided into at least the following four subgroups:

(a) Large standard IC firms carrying out design and large-scale manufacturing;

(b) Smaller ASIC producers carrying out design and manufacturing;

(c) Specialized design firms, which process their designs in silicon foundries. These firms may also specialize in developing design aids;

(d) Silicon foundries which process circuits designed by specialized design houses and by the IC using firms themselves.

Some firms may be active in more than one of these subgroups.

C. The integrated circuits industry of the Republic of Korea*

1. The electronics industry of the Republic of Korea

The electronics industry of the Republic of Korea started in 1959 with the local assembly of radios. Production was initially oriented towards the local market. In the mid-1960s, the export market began to constitute the dominant source of demand for the electronics industry of the Republic of Korea. Much of the growth in production in the 1960s was due to the establishment of foreign firms producing components and sub-assemblies for export. In the late 1960s these foreign firms accounted for one third of the output and three-quarters of the exports from the Republic of Korea. In 1969 a number of changes occurred. As Mody ([31], p. 4) states:

> "In 1969, some years after foreign firms had been in operation, the Government of the Republic of Korea took a major new initiative to restructure the electronics industry. The Electronics Industry Promotion Law was passed and an eight-year development plan was introduced and initiated. Exports of electronics products were a major focus of these initiatives."

Four main changes took place thereafter. First, production rose dramatically (see table 5). Secondly, joint venture firms became common. Thirdly, as may be seen from table 6, there was a greater concentration on components production until 1973, when consumer electronics began to increase its share of the output of the electronics industry. The share of production of industrial electronics fell drastically in the early 1970s, and it was not until very recently that it started to increase again. Fourthly, exports grew much faster than production (see table 5). Exports reached 80 per cent of production in 1973 and stayed high until very recently, when the domestic market became an important outlet for electronic products of the Republic of Korea.

Table 5. Basic data on the electronics industry in the Republic of Korea (Millions of dollars)

Year	Production	Exports	Imports	Apparent consumption	Exports production ratio (percentage)	Imports consumption ratio (percentage)
1968	56	19	40	77	34	52
1969	..	..	..	..	..	..
1970	106	55	70	121	52	58

continued

*This section draws heavily on Mody [31], pp. 1-18.

Table 5 (continued)

Year	Produc-tion	Exports	Imports	Apparent consump-tion	Exports produc-tion ratio (percent-age)	Imports consump-tion ratio (percent-age)
1971	138	88	111	161	64	69
1972	208	142	170	236	68	72
1973	462	369	326	419	80	78
1974	814	518	446	742	64	60
1975	860	582	445	723	68	62
1976	1 422	1 037	699	1 084	73	64
1977	1 758	1 107	847	1 498	63	57
1978	2 270	1 359	1 156	2 067	60	56
1979	3 280	1 845	1 386	2 821	56	49
1980	2 852	2 004	1 460	2 308	70	63
1981	3 791	2 218	1 774	3 347	59	53
1982	4 006	2 144	1 979	3 841	54	52
1983	5 558	2 977	2 683	5 264	54	51

Source: Mody [31], table 1.1.

Table 6. Composition of electronics production and exports of the Republic of Korea
(Percentage)

Year	Production			Exports		
	Consumer goods	Indus-trial equipment	Parts and compo-nents	Consumer goods	Indus-trial equipment	Parts and compo-nents
1965	47	20	33	72	--	28
1966	45	34	21	76	1	23
1967	44	29	27	30	1	69
1968	30	28	43	18	1	81
1969	31	21	50	17	1	82
1970	28	16	56	16	--	84
1971	24	14	62	13	--	87
1972	26	12	62	25	3	72
1973	29	9	62	28	5	67
1974	32	9	59	33	5	62
1975	31	11	58	38	5	57
1976	39	9	52	38	5	57
1977	36	10	50	40	9	51

continued

Table 6 (continued)

Year	Production			Exports		
	Consumer goods	Industrial equipment	Parts and components	Consumer goods	Industrial equipment	Parts and components
1978	41	9	50	48	8	44
1979	42	10	48	50	6	44
1980	40	13	47	49	6	45
1981	42	13	45	51	6	44
1982	39	16	45	42	10	48
1983	39	17	44	40	15	45

Source: Mody [31], table 1.2.

Since the end of the 1970s three major changes have occurred. First, employment has decreased slightly despite a very large increase in production. Thus, between 1978 and 1983 the number of employees dropped by 5 per cent, despite a growth in the value of production (in nominal United States dollars) of 145 per cent ([5], p. 2, p. 305 and table 5).

As Mody ([31], p. 9) states: "Quite clearly, the phase of electronics as a labour-absorbing industry is over. Even component manufacturers, traditionally the most labour-intensive segment of the industry, have had to automate to stay competitive". A case in point is that of a pure assembly plant for ICs in the Republic of Korea, owned by a United States firm, that doubled output at the same time as it cut its work-force by nearly half, from 4,500 to 2,500 workers ([3], p. 35).

Secondly, a product diversification is taking place. As may be seen from table 6, industrial electronics is now an important part of the electronics industry in the Republic of Korea. For example, in 1983 firms in the Republic of Korea produced telephone switching systems worth $151 million, telephone sets worth $191 million and personal computers worth $39 million ([5], p. 2). In the field of consumer electronics, television sets have become very important. In particular, the production of colour television sets has grown considerably. In 1983 over 4 million colour television sets were produced in the Republic of Korea, 2.5 million of which were exported. The total value of production of television sets, including black-and-white, amounted in the same year to $1.2 billion. It is hoped that videotape recorders will be the next large consumer electronics product. As will be seen below, the electronic components industry is also diversifying.

Another indicator that the Republic of Korea is moving away from "simple electronics" is its emphasis on research and development. Samsung claimed that it spent $25 million on electronics research and development in 1983 and that in 1986 its research and development expenditures would reach 5 per cent of sales ([4], p. 87). Business Korea ([5], p. 61) suggested, however, that Samsung's research and development spending on semiconductors until 1984 amounted to around $15 million. Total research and development in the semiconductor field by five leading firms until 1984 amounted to $40 million and was expected to be $51 million in 1985 (see table 11), based on an exchange rate of 850 won per dollar.

Thirdly, as was noted above, the domestic market has taken a larger share of the output of electronics products in the Republic of Korea. This applies to all three subsectors (see table 7).

Table 7. Export share of electronics products of the Republic of Korea (Percentage)

Year	Consumer goods	Industrial equipment	Parts and components	Total
1968	..	..	..	35
1970	30	2	78	51
1971	30	2	90	68
1972	64	16	80	68
1973	77	43	87	79
1974	66	36	67	63
1975	74	37	70	67
1976	71	44	80	72
1977	64	57	64	62
1978	71	59	53	59
1979	66	35	52	56
1980	86	32	67	70
1981	71	25	56	58
1982	58	32	57	53
1983	55	46	56	53

Source: Mody [31], table 1.5.

2. The structure of the electronics industry

As was noted above, there has been an important element of foreign participation in the electronics industry of the Republic of Korea since the 1960s. The foreign element is still large, but at least in terms of the share of foreign firms, including joint ventures, in the output of electronic products, it is declining. Mody [31] argues that the share of domestic firms increased from 50 per cent in 1979 to nearly two thirds in 1983. The declining share of foreign firms is no surprising in light of the product diversification described above The foreign firms are nearly 100 per cent export-oriented, while the product diversification to an important extent is based on the growing domestic market. For example, in 1983, the domestic market accounted for over 50 per cent of the sales value of colour television sets ([15], vol. 2, p. 24).

Among the domestic firms, three large conglomerates dominate the industry. These are Samsung, which in 1983 sold electronic goods valued at $835 million, Gold Star, with sales of $883 million, and Daewoo, whose exact sales were not known at the time of writing ([4], p. 85). According to Mouy [31], these three groups account for 40 per cent of production and export of electronics goods of the Republic of Korea (this would imply that Daewoo accounts for slightly less than 10 per cent of production). If Mody is correct, and if the sales of the three groups are divided by the sales figure of domestic firms in 1983, their share would rise to 62 per cent. Mody ([31], p. 29) also argues that their share in the market for finished products, as distinct from components, is even higher. For example, their share of sales of television sets in 1982 was as high as 94 per cent ([31], table 2.1). In microwave ovens there is a duopoly shared by Gold Star and Samsung. The level of concentration is also high in the case of some components such as advanced ICs (see more below) and cathode-ray tubes for television sets ([31], p. 29).

Another large conglomerate, Hyundai, is currently moving into electronics production and investing massive amounts of capital into this industry. Furthermore, there is a large number of smaller firms in the industry. In 1983 the Electronics Industry Association of Korea claimed that there were 451 electronics firms. Only 41 of these had more than 1,000 employees ([15], vol. 2, p. 302), consisting mainly of component manufacturers, a category which includes both firms producing passive components and firms merely packaging ICs ([31], p. 33).

3. The components industry

The total production value of electronic components in 1983 amounted to over $2.4 billion. Of this sum, exports amounted to 45 per cent, or over $1.3 billion. Semiconductor production amounted to $850 million, and within this group ICs accounted for $661 million. The value of IC production has increased dramatically since the early 1970s, rising from $30 million in 1971 to $661 million in 1983 (see table 8). It should be noted that these official statistics may well underestimate the true value of production, since the in-house consumption in large firms like Gold Star and Samsung may not be included. This would also mean that the apparent consumption figure in table 8 would be an underestimation of the true market. Indeed, one executive of an electronics firm in the Republic of Korea argued in 1984 that the domestic market for ICs was worth $300 million.

As may be seen from table 8, nearly 100 per cent of local production is exported and the requirements of the local market are met mainly by imports. The inclusion of in-house production of ICs by Gold Star, Samsung etc. would only marginally alter this picture. This reflects the fact that the overwhelming majority of ICs produced in the Republic of Korea are only assembled and tested

Table 8. Production, trade and apparent consumption of ICs by the Republic of Korea, 1971-1983 (Millions of dollars)

Year	Production	Exports	Imports	Apparent consumption
1971	30	30	0	0
1972	50	50	0	0
1973	116	116	1	1
1974	159	144	4	19
1975	129	105	8	32
1976	189	180	18	27
1977	208	202	34	40
1978	236	222	44	56
1979	289	281	68	76
1980	294	321 a/	81	81
1981	342	343 a/	101	101
1982	490	498 a/	88	88
1983	661	658	161	168

Source: [21].

a/ Exports exceed production, which presumably means that a reduction in stocks took place.

there. Before 1986, only three firms had their own wafer production. These firms were Gold Star, Samsung and Korea Electronics Corporation. In 1986 Hyundai also started wafer production. In assembly production there are mainly foreign firms, with the biggest totally domestic-owned firm being Anam Industrial ([3], p. 34). Anam is said to be the largest subcontracting semiconductor assembly firm in the Republic of Korea*. Among the other assembly firms is Korea Electronics Corporation, with 6.25 per cent of its equity owned by Toshiba, Fairchild, Motorola and Signetics. Around 10 firms are simple IC assemblers ([4], p. 34).

The market for ICs in the Republic of Korea is large. It is valued at $168 million (plus in-house consumption), as compared with a market of $418 million in the Federal Republic of Germany, $332 million in France, $211 million in Italy and $550 million in the United Kingdom ([42], p. 42). Historically, the market in the Republic of Korea has been dominated by consumer products, but the recent diversification into professional electronics has created a demand for ICs for these types of products also. Tables 9 and 10 provide an estimate of the market for the different types of ICs

*Based on interview with Lee Kyung Tae of the Korea Institute of Economics and Technology.

used in various types of consumer and professional electronics products. Somewhat surprisingly, the professional electronics sector accounted for a larger share of the market for ICs, in terms of units, than the consumer electronics market in 1983. Among the professional electronics products, ICs were mainly used for computer terminals, telephone exchange systems and personal computers. Among the consumer goods, ICs were mainly used for tape recorders, colour television sets and high-fidelity equipment.

(a) Firms producing integrated circuits*

(i) Samsung Semiconductor and Telecommunications Co. Ltd.

Samsung Semiconductor and Telecommunications Co. Ltd. (SST) is a part of the Samsung business conglomerate. Samsung is one of the larger conglomerates in the Republic of Korea, having recorded a total sales value of $7 billion in 1983. This represented nearly 10 per cent of the gross national product (GNP) of the Republic of Korea in that year [38].

SST produces both telecommunications equipment and semiconductors. All stages in IC production are carried out within SST. In 1983 the total production value amounted to $103 million, $25 million of which were accounted for by semiconductors, including ICs worth $14 million and transistors accounting for the rest. The bulk of the ICs consisted of CMOS devices produced for consumer products such as watches, toys, television sets and radios, valued at $10.6 million. Over 95 million units were produced. The rest of IC production consisted of linear ICs, 19 million units of which were produced. As is discussed more below, SST is involved in a very ambitious expansion of IC production. For 1985 they estimated that their total semiconductor sales would be $180 million, or a sevenfold increase compared with 1983 ([28], p. 11). SST employs a work-force of approximately 4,500, approximately one half of whom work with semiconductors.

Semiconductor production began in 1974 through a joint venture involving the United States company ICII and Korea S/C Company Ltd. In December 1974 the joint undertaking began producing MOS LSI (metal oxide semiconductor - large-scale integration) devices for wrist-watches. The operations performed in the Republic of Korea were mainly limited to packaging. In 1977 it began, for the first time in the Republic of Korea, to produce bipolar transistors. Most of the technology came from ICII. In 1978 the United States firm withdrew its capital and Samsung acquired the stock. In July 1978 the new undertaking developed its own IC for multi-function wrist-watches. It also developed a CMOS LSI device, and claims to dominate the world market for ICs for wrist-watches. However, such ICs are simple. In 1980 the firm was taken over by

---

*Unless otherwise indicated, the information provided in this section is based on interviews with firm representatives.

Table 9. Estimated demand for ICs for the consumer electronics industry in the Republic of Korea, 1983
(Thousands of units)

Item	Production	MOS logic	MOS micro-computer a/	MOS memory	Bipolar digital	Bipolar linear	Total
Colour television sets	4 563	6 844	4 563	4 563	6 844	22 815	45 629
Black and white television sets	4 589	--	--	--	--	11 467	11 467
Radios	2 338	2 338	--	--	--	9 014	9 352
Hi-fidelity units	4 358	6 539	4 358	892	4 358	23 969	40 094
Tape-recorders	14 289	28 574	14 289	--	14 289	28 574	85 722
Videotape-recorders	152	1 520	380	--	456	1 976	4 332
Electronic watches	11 342	11 342	11 342	--	--	--	22 684
Refrigerators	1 386	2 772	1 386	--	1 386	1 386	6 930
Washing machines	445	--	445	--	--	--	445
Microwave ovens	963	2 889	963	--	1 926	1 826	7 704
Air conditioners	86	86	86	--	86	258	516
Total	44 509	62 902	37 810	5 435	29 343	99 385	234 875

Source: [21].

a/ One-chip microcomputer.

Table 10. Estimated demand for ICs for industrial use in the Republic of Korea, 1983
(Thousands of units)

Item	Production	MOS logic	MOS micro-computer a/	MOS memory	Bipolar digital	Bipolar linear	Total
Personal computers	359	10 910	359	5 385	9 282	1 091	26 775
Floppy discs	28	196	--	--	168	112	476
Printers	15	120	15	75	137	60	405
Monitors	730	--	--	--	1 095	2 920	4 015
Telephone sets	5 778	5 798	--	2 899	5 798	5 798	20 293
Transmitters and receivers	1 131	1 131	1 131	3 393	3 393	3 393	12 441
Facsimile apparatus	1	5	1	3	10	7	26
Calculators	2 869	--	2 869	--	--	--	2 869
Intercom systems	987	987	494	987	1 480	1 974	5 922
Alarms	1 654	1 654	--	--	1 654	3 308	6 616
Telephone exchange systems	610	12 200	610	21 960	18 300	18 300	71 390
Telephone recorders	550	295	--	--	550	2 200	3 025
Computer terminals	960	24 000	960	11 520	19 200	28 800	84 480
Automobiles	219	654	219	1 085	2 190	1 085	5 208
Testing equipment	3 246	..	..	..	..	..	..
Total	19 153	59 727	6 654	49 277	63 235	69 028	243 921

Source: [21].

a/ One-chip microcomputer.

the Samsung electronic company and became one of its divisions. The same year it developed four ICs for black and white television sets made for domestic use. As was mentioned above, the production of television sets is very large in the Republic of Korea, and Samsung is one of the largest producers. In 1981, it developed the NTSC/PAL CHROMA IC for colour television sets. Its ordinary supplier did not sell Samsung as many ICs as it needed, supposedly on account of a world shortage of such ICs. As distinct from ICs for wrist-watches, this is a high-technology item that Samsung mastered through reverse engineering. Thus, since ICII left the company, it relied fully on its own design development of ICs until 1983.

In 1983 SST made an agreement to introduce 16K static random access memory (SRAM) and 256K ROM from Sharp in Japan. In the same year it established a firm in California for the purpose of technology absorption and design of ICs, and made an agreement with MICRON of the United States to produce 64K and 256K DRAM. Hence the IC product design was bought from abroad. SST claims to have built up the process itself, although most of the equipment was imported. The plant was constructed by May 1984, and the process technology developed as early as November 1984. Samsung claims that it has spent $125 million on its specialized plant for the production of very large-scale integrated circuits ([3], p. 28). A total of $340 million is planned to be spent on this project during a five-year period [38].

At the end of 1984, company sources claimed that pilot production of 64K DRAM was under way and even available for export. The target was to produce as many units per month as the largest producer in the world ([41], p. 103), in other words, 6 million units per month of 64K DRAM chips. The plan was subsequently reduced to 3 million per month, and other, simpler, ICs are currently being produced in a converted factory originally intended to produce 64K DRAM ([5], p. 62). Finally, in 1984 SST developed a custom-designed IC for telephone sets (speech. dial and tone functions) and these are under pilot manufacturing. Although SST also produces electronic switching equipment, it does not produce ICs for this product.

SST has about 100 design engineers and a special research and development centre for ICs, in addition to three CAD units. The engineers are said to be already working on the development of mask designs for a 256K DRAM chip, and company sources say that SST is building a plant for the production of 256K DRAM. According to one source, Samsung dedicated a new plant to the production of 256K DRAM in June 1985 ([28], p. 11). A range of other advanced ICs are also said to be on the development list ([3], p. 28).

There has thus been a marked change in the orientation of the semiconductor division of SST. Advanced standard ICs for use in professional electronics are emphasized instead of simpler ICs for consumer goods. Samsung is therefore aiming at participation in another sphere with greater resource requirements and greater risks. This matter will be further discussed below.

(ii) Gold Star Semiconductor Ltd.

Gold Star Semiconductor Ltd. (GSS) is a part of the Lucky-Gold Star conglomerate. This group had a sales value of $5.6 billion in 1981, which represented approximately 9 per cent of the GNP of the Republic of Korea. The Lucky-Gold Star group was started in 1958 and produces a range of electronic and electrical goods, including television sets, microwave ovens, audio equipment and computers. The activities of the group also cover fields other than electronics, for example chemicals, construction and trade.

GSS was established in 1979 to work on solid-state electronics, with a speciality in telecommunications equipment. It is a joint venture with the United States firm AT&T which owns 44 per cent of the stock. GSS produces, apart from telecommunications equipment, computers and semiconductors. The sales figures of GSS rose from only $5 million in 1981 to $42 million in 1982 and $64 million in 1983. The sales value was planned to reach $120 million in 1984. Electronic switching systems account for about 70 per cent of the sales, computers for 10 per cent and semiconductors for 20 per cent. Thus, sales of semiconductors were planned to be in the order of $24 million in 1984. GSS has 1,800 employees, 700 of which work in the semiconductor division.

GSS mainly provides the Lucky-Gold Star conglomerate with ICs. The Executive Director of GSS explained that it has to satisfy as much as possible of the demand for ICs within the conglomerate. It therefore produces a range of different ICs, linear and digital, for both consumer and professional electronics products. It also produces, with a design from AT&T, hybrid ICs for telecommunications equipment produced by GSS.

In 1980, GSS began producing semiconductors. The first products were standard ICs, such as linear ones of SSI and MSI complexity. These were used for television sets, radios etc. In 1981 it began production of computers as well as telecommunications equipment At the end of 1982 it reached an agreement with AT&T for the production of an advanced telecommunications system and VLSI circuits. According to Business Korea ([3], p. 29), GSS had reached the pilot stage of manufacturing 64K DRAM with the assistance of AT&T. GSS was also said to be receiving the process technology for 256K DRAM from AT&T. One industrial observer claims that they are getting this technology in return for supplying thin film hybrids to AT&T. However, another source recently claimed that GSS has "... all but abandoned plans to produce 256K chips for exports" ([28], p. 11). Instead, the firm appears t' put some emphasis on the production of 64K SRAM chips, a product which is not so badly affected by international price changes as the DRAM market ([28], p. 11 and [5], p. 34).

In April 1983, GSS began work on an 8-bit microprocessor under licence from Zilog. This type of IC is to be used in, for example, personal computers. Business Korea ([3], p. 29) claims that there are only five producers of this processor in the world. GSS is, however, only allowed to export it to Asian countries.

In 1984, GSS reached an agreement on CMOS technology with the United States firm LSI Logic. The technology will be used for making custom-designed ICs based on the gate-array design mode. GSS was to start producing custom-designed ICs at the end of 1984. The first phase of implementation of the agreement was to involve the sale of wafers to LSI Logic, and in the second phase they would be selling on the domestic market, both within the conglomerate and to other firms of the Republic of Korea. GSS says that it also has a licence on uncommited logic array (ULA) technology from Bell, which is used for custom-designed ICs The technologies from both LSI Logic and Bell will be used for .ewly developed products rather than as substitutes for previously imported components. GSS is in the process of developing a custom-designed IC for telephones. Previously, GSS had copied an IC for speech functions only, which had become obsolete. A new circuit incorporating several types of functions on one chip is on the development list. Custom-designed ICs have been worked on since 1982. GSS produces such ICs, probably in very small numbers, for colour television sets, modem devices and audio equipment. On the whole, GSS follows a much more cautious strategy than SST. The company sees itself more as a manufacturer of logic and custom chips for United States companies than as an independent unit. As one executive puts it: "We can be a very good manufacturing arm for other companies, and we can be a very good marketing arm in this part of the world" ([28], p. 11).

Of the 700 employees in the semiconductor division, 100 are design and process engineers. Six of these have Ph.D. degrees from the United States. The availability of design engineers is not seen as a problem owing to the great flexibility of the educational system in the Republic of Korea. There is, however, a severe shortage of experienced design engineers.

The Executive Director of the firm conceded that the future orientation of GSS with regard to ICs is not very clear. He suggested, however, the possibility of greater specialization in the field of custom-made ICs.

4. Analysis and conclusions

The electronics industry of the Republic of Korea has been extremely successful in terms of production and exports. Gaule [20] points out that it is the tenth largest producer and the ninth largest exporter of electronics products in the world. For components, and in particular ICs, the performance is equally spectacular in both the production and export fields. In terms of value added and own design development, it is however only in the last 10 years that performance has improved. In 1974 Samsung began its own wafer production and was followed by Gold Star five years later. Their production of wafers is, however, only a fraction of the total domestic IC production of nearly $700 million, but is still much larger than Indian production (see below). There is, nevertheless, a dynamism within the industry of the Republic of Korea that will in all likelihood lead, in latter half of the 1980s, to a great increase in the share of production accounted for by fully integrated, domestically-owned plants. The leading firms are investing large amounts of money in new plants and acquiring much new technology. Equally important, they are investing in research and development and have built up sizeable design departments. For one estimate of the investment in plant and research and development of firms in the Republic of Korea, see table 11. The table shows that research and development expenditures by SST are small compared with the leading IC producers globally, but SST has, as yet, a very narrow range of products that reduces the need for research and development. Furthermore, it has a technology transfer agreement with the United States firm Micron for the design of 64K and 256K DRAM, which again reduces the need for its own research and development.

Table 11. Investments of semiconductor companies in the Republic of Korea (Millions of dollars) a/

Item	Investments			
	Until 1984	1985 b/	1986 b/	1987 b/
Plant				
SST	275	268	113	106
GSS	94	61	30	11
Korea Electronics	33	20	17	20
Hyundai Electronics	127	129	19	22
Anam Industrial	87	68	49	23
Subtotal	616	546	228	182
Research and development				
SST	15	29	27	28
GSS	15	7	4	4
Korea Electronics	2	2	3	6
Hyundai Electronics	7	12	2	8
Anam Industrial	1	1	1	1
Subtotal	40	51	37	47

Source: [5], p. 61.

a/ Based on exchange rate of $1 = 850 won.

b/ Planned investment.

The strategy pursued by the electronics industry in the Republic of Korea may prove to be highly successful. An attempt will now be made to explain why this seems likely.

The domestic market for ICs began to be fairly sizeable a decade ago, as was shown in table 8. Indeed, as was mentioned above in subsection 3 on the components industry, the market for ICs in the Republic of Korea may well be even larger than what the statistics show, since the production of GSS and SST for use within the conglomerates may not be included. The size of the market compares favourably with that of some European countries. For example, it was 80 per cent of the Italian and half of the French market in 1983. Furthermore, to the extent that the fast growth of the electronics industry in the Republic of Korea will imply an equivalent demand for ICs, the domestic market will probably grow very fast in the future.

A large domestic market does not necessarily mean large domestic production. However, in the 1970s it was evident that the Japanese suppliers of ICs controlled the output and quality of the television industry, as well as other electronics products, in the Republic of Korea, through their control of critical components. In the case of videotape recorders the Japanese suppliers simply did not supply the latest ICs, while for calculators they ceased to supply the required ICs.* These problems were acute at the end of the 1970s and industrialists in the Republic of Korea began to realize that they had to integrate backwards into IC production in order to reduce the predominance of the Japanese. A case in point was ICs for colour television sets produced by Samsung (see the preceding subsection (a) on firms producing integrated circuits). The Government also became involved in this matter when it demanded that Ericsson should supply custom-designed IC technology to the Republic of Korea as a part of a contract for telecommunications equipment. The custom-designed IC technology was meant to be used for videotape recorders.

The production of ICs thus became of "strategic" importance, since the availability and quality of such components were seen as being a prime determinant of the performance of the downstream industries, mainly the consumer electronics industry. The term strategic can however be used in another sense than that of being essentially a substitution for (non-available) imports. As was seen in section B on the international industry, ASICs are gaining market shares at the expense of standardized ICs. This expansion in the market is partly seen as a function of lower costs of custom-designed ICs in some applications, but also as a function of the importance of custom-designed ICs in the innovative process. Firms in the Republic of Korea have hitherto concentrated heavily on standard ICs. Very recently, however, some efforts have been made in the area of custom-designed ICs, for example by Gold Star.

The reason behind the little interest in custom designed ICs has probably been the relatively weak design capabilities in the domestic industry. The Republic of Korea is, with some exceptions,

---

*Based on interview with Kim Choong-ki, Department of Electrical Engineering, Korea Advanced Institute of Science and Technology.

a production site. Frequently, production of, for example, electronic and mechanical products is undertaken by firms acting as subcontractors for foreign firms. In other cases, production is made under a licence from a foreign firm. The knowledge of the design process is thus not very deep, and the IC-using firmsof the Republic of Korea often do not have the incentive or the skills to formulate the specifications for a custom-designed IC. The custom-designed ICs used in the products are therefore instead often supplied by a manufacturer that has a close relationship with the firm providing the licence. Furthermore, being a subcontractor requires considerable flexibility and rapid response to new requirements. Since it may take a year to custom-design an IC, firms in the Republic of Korea cannot wait for one to be produced.

The situation is probably changing now, in particular with the growing importance of professional electronics and advanced consumer electronics products, such as videotape recorders, in the output of firms in the Republic of Korea. The interest in the gate-array design method shown by GSS reflects this change in the electronics industry. A representative of the Electronics Industry Association of Korea has referred to plans for the production of custom-designed ICs for videotape recorders. In the preceding subsection on IC-producing firms, it was noted that GSS has already copied a custom-designed IC for telephones, which, according to one industry source,* is the largest user sector of custom-designed ICs in Korea today.

Thus, the market for ICs in the Republic of Korea is large and the firms have special incentives to develop it. How did the local IC market develop as it did in the 1970s? One factor was the export orientation of the domestic electronics industry. The export orientation of firms linked to foreign manufacturers is well known, but, as was shown in the above subsection on the structure of the electronics industry, there are also large domestically owned firms that export electronics products. The export orientation has allowed a large growth in production, not because the domestic market is inherently small (it is in fact as large as production), but because the export orientation of firms has allowed them to specialize in particular items and thereby reduce costs and gain in competitiveness. Had an attempt been made to cover, through domestic production, the entire range of products consumed in the country, then output per product would have been reduced and prices increased, which in turn would have reduced demand and production.

The above reasoning refers mainly to the consumer electronics field. For the component industry the early export orientation in the form of local assembly of ICs seems to have had little impact on the generation of an integrated IC industry in the Republic of Korea. Of the many firms that began the assembly of ICs at the end

---

*Based on interview with Park Kwang Won, Director of Kortronics Enterprise.

of the 1960s and in the early 1970s, only one has begun producing wafers, and this was done only recently. On the other hand, assembly technology in the Republic of Korea is said to be well developed in firms that do not solely assemble ICs, a fact that is probably related to their long experience of assembly (Gaule [20] makes a general point about the importance of mobility of personnel in the Korean electronics industry).

The size of the domestic market for electronics products is another important variable. Mody [31] suggests that the market in the Republic of Korea is about 2.5 times the size of the Indian market. In particular, the market for home electronics products such as television sets and sound recorders is large in the Republic of Korea. As was shown in table 10, such consumer electronics products demanded most of the ICs made in the Republic of Korea in 1983. Of the 234 million IC units demanded for consumer goods, 86 million went to tape recorders, 57 million to television sets and 40 million to high-fidelity equipment. The export share of these products considered alone, using a weighted average, was only 54 per cent in 1983.*

The importance of the domestic market, at least in 1983, was even more pronounced for professional electronics. The three largest users of ICs in professional electronics products in 1983 were computer terminals, telephone exchange systems and personal computers. The weighted export average of these three types of products in that year was only 32 per cent. Thus, the home market for both consumer electronics and professional electronics products is a very important determinant of demand for ICs in the Republic of Korea.

The development of a large demand for ICs is dependent upon the dynamism of the IC-using industry. As was argued above in subsection 2, there is an oligopolistic market structure in the electronics industry, the main firms being GSS, SST and Daewoo. Mody ([31], p. 31) makes the important point that the product ranges of these firms overlap and that there is an intense competition between them, extending to external markets as well. Gaule [20] also stresses, in the case of television sets, the intense domestic competition.

Government policies have played a role in shaping the electronics industry in the Republic of Korea and, indirectly, the demand for ICs. In 1969 the Electronics Industry Promotion Law was passed. The major focus of the law was, according to Gaule [20] and Mody [31], exports of electronics products. Foreign firms were invited to enter the country on favourable terms, transfer of technology was supported and an export zone was created for the electronics industry.

Import restrictions have also been applied generously, both for components and for final products. For example, in 1980, there

---

*Calculated on the basis of data contained in [15].

were practically no imports of television sets [1]. Similarly, imports were not allowed in the mid-1980s for personal computers [20]. This means that the 1982-1983 market for personal computers, which amounted to more than 50,000 units, was reserved for local suppliers.

With regard to national research and development activities, the Korea Institute of Electronics Technology (KIET) is the most important national laboratory in the IC field. KIET, which began operating in 1976, was mainly funded by the Ministry of Science and Technology, but the World Bank contributed $29 million in 1972. In the mid-1980s yearly funding is around $15 million, and there are 200 people on the technical staff. KIET has a full-scale wafer fabrication facility for both MOS and bipolar ICs. In addition, computer development activities are carried out. In the IC field, KIET has successfully developed prototypes of videotape recorder chips, an 8-bit microprocessor chip, as well as memory chips (4K SRAM and 32K and 64K ROMs). The ROM memories have also been produced in quantity. The processing was done with 4-5 micrometer technology ([45], pp. 10-17; [31], pp. 70-71). In 1985 KIET was being merged with the Korea Electrical and Telecommunications Research Institute to form a new organization called the Korea Electronics and Telecommunications Research Institute.

The use of credit facilities has also been discussed in this industry, according to Gaule [20]. He notes that credit facilities were used simultaneously with the application of import restrictions on components, thus not only providing a market for domestic producers but also supplying them with the means of production. According to Business Korea ([3], p. 27), the Government of the Republic of Korea was to lend approximately $350 million to the semiconductor industry during 1983-1986 under the Semiconductor Industry Fostering Plan initiated in 1983. In comparison, the total fixed investment plans of the leading firms for the period 1985-1987 amounted to $955 million (see table 11). Koreans emphasize however that the investments made had so far been mostly initiated by companies rather than by the Government ([5], p. 62). In addition, the Semiconductor Industry Fostering Plan was not implemented as had been planned.*

Finally, the decision-making process in the Republic of Korea appears to be very swift, judging by the Samsung 64K DRAM case. Resources are mobilized quickly within large conglomerates and invested in very risky products in a manner that would require State intervention in countries without such large conglomerates. The existence of the conglomerates - an institutional factor - is very important for a product like ICs becuase of the large barriers to entry and high risks involved, especially with regard to standard ICs. It is partly for this reason that no company in a technologically advanced country like Sweden is producing standard ICs.

---

*Based on communication received from Lee Kyung Tae of the Korea Institute of Economics and Technology.

D. The integrated circuits industry of India

1. The electronics industry of India

The Indian electronics industry began with the setting-up in 1948 of the public sector company, Indian Telephone Industries (ITI), to manufacture telecommunications equipment for the public telephone system. Then, in 1954, Bharat Electronics Ltd. (BEL) was set up to manufacture electronic equipment for the armed services. The mid-1950s saw the local production of radio receivers on the basis of technology licensed from abroad. In the 1960s, while consumer electronics production continued at a relatively low level, the public sector company Instrumentation Ltd. was set up to manufacture process control instrumentation for India's growing power, oil, cement and other process plants. In 1967, the public sector company, Electronics Corporation of India Ltd. (ECIL) was formed out of the nucleus of semi-commercial production built up over the preceding 5 years in the Bhabha Atomic Research Centre. ECIL products covered nuclear, medical and general-purpose test and measuring instruments, analogue and digital computers, electronic control systems for nuclear and process plants and some types of the electronic components [36]. While the production of ITI, BEL and Instrumentation Ltd. was based on technology licensed from abroad, that of ECIL was entirely based on locally developed technology.*

In 1970, the Electronics Commission and the Department of Electronics were established as the policy-making and executive bodies respectively for the development of the entire electronics industry in India ([40], p. 271). Associated with the establishment of this agency, government policy began to place greater emphasis on professional electronics, particularly on control and instrumentation and computers, in addition to the emphasis placed until then on the defence and telecommunications aspects of the electronics industry ([31], p. 21). Data on the production of electronics equipment and components in India during the period 1971-1985 are provided in table 12. Total output amounted to the equivalent of $1.3 billion in 1983, $2 billion in 1984 and $2.4 billion in 1985.

(a) The structure of the electronics industry

Three types of firms exist within the electronics industry of India. Public sector firms, organized private sector firms and small-scale firms. Their respective shares of output in 1981 within different areas of the electronics industry are shown in table 13. Small-scale industry accounted for the remarkably high share of two thirds of the output of consumer electronics goods and for a third of the output of the entire electronics industry. This was a direct effect of the government policy of reserving a number of activities for small-scale industries. Such industries also account for one third of component production, consisting primarily

*Communication received from A. Parthasarathi.

Table 12. Breakdown of Indian electronics production by industry, 1971-1985 (Percentages)

Industry	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Consumer electronics	30	31	27	25	22	25	25	27	28	27	29	28	24	31	39
Communications and broadcasting equipment	23	24	26	24	27	27	25	22	20	23	18	21	20	17	14
Aerospace and defence equipment	16	15	14	16	12	12	11	11	9	8	8	9	9	8	7
Computers, control instrumentation and industrial electronics	8	9	10	11	16	16	20	20	20	20	22	20	24	23	21
Components	23	22	22	24	21	20	18	20	21	20	20	18	17	16	15
Production in the Santacruz Electronics Export Processing Zone, the Kandla Free Trade Zone and bonded factories	--	--	.	--	1	1	1	1	2	2	2	4	6	5	3
Total production in millions of rupees	1 730	2 000	2 280	3 010	3 645	4 100	5 085	5 905	6 465	8 060	8 560	12 050	13 600	18 900	26 600
Total production in millions of dollars	230	260	300	390	450	530	630	730	800	1 000	950	1 255	1 347	2 000	2 460

Sources: [31], table 1.18, for 1971-1983; [19] for 1984; and [24] for 1985.

Table 13. Breakdown of electronics production in India by type of enterprise, 1981

Industry	Total production (millions of dollars)	Type of enterprise: Public sector (percentage)	Private sector (percentage)	Small-scale (percentage)
Consumer electronics	273	9.02	24.56	66.42
Communications and broadcasting equipment	171	95.17	4.83	--
Aerospace and defence equipment	77	99.49	0.51	--
Control instrumentation and industrial electronics	173	35.39	28.49	36.12
Computers and office equipment	36	30.15	42.16	27.69
Electronic components	192	28.03	39.15	32.82
Total a/	922	43.25	23.02	33.73

Source: [39].

a/ Excluding production worth $25 million in the Santacruz Electronics Export Processing Zone.

of components requiring low investments and simple assembly techniques for use in consumer electronics [32]. Public sector firms dominate in industries producing communications and broadcasting equipment and in the aerospace and defence industries. They also account for one third of the output of control instrumentation and industrial electronics equipment. Three public sector undertakings dominate the large-scale electronics industry. These are BEL, ECIL and ITI, which, according to Mody [31], accounted for 25-30 per cent of Indian electronics products in the early 1980s. If small-scale industries are excluded, the share of the three biggest firms would rise to approximately 42 per cent. Although they show some overlapping in terms of their product ranges, Mody ([31], p. 36) states that "there has been little competition between these firms".

Other actors are the public sector companies of the different states of India, the emergence of which in the period 1978-1985 is an important development in the Indian electronics industry. The output of these companies, which currently operate in seven states,* amounted to $140 million in 1985, or approximately 6 per cent of the total output of the Indian electronics industry. Moreover, while the whole industry grew by 39 and 41 per cent in 1984 and 1985, respectively, the State Electronics Corporations grew by 45 and 50 per cent.* In 1985, the public sector companies, central as well as state, accounted for 40 per cent of production of the Indian electronics industry.* Finally, firms in the organized private sector, which provided less than one quarter of output in 1981, have only a modest share of the small market for computer and office equipment and components.

The Indian electronics industry has been nearly completely oriented towards the requirements of the domestic market. Total exports of electronics products were valued at approximately $8 million in 1972-1973 (2.9 per cent of production), and increased to approximately $155 million in 1984 (8.2 per cent of production) ([25], p. 111). More than half of these exports came from the Santacruz Electronics Export Processing Zone. Other exports amounted to a mere 3.4 per cent of production in 1982 ([25], p. 112). Imports are estimated to have accounted for between 35 and 40 per cent of domestic demand ([25], p. 9).

(b) Indian electronics policy

In the early 1970s, the Government of India assumed an active role with regard to electronics and the first steps towards evolving a national strategy were taken. The Department of Electronics was established in 1970 and the Electronics Commission in 1971. In 1975, a five-year plan (1974-1979) for the electronics industry was adopted. The plan emphasized self-reliance, regional dispersion and employment generation, as well as the importance of large-scale integrated circuits, as the following passage shows:

> "Memory design and memory manufacture has now become a speciality and the trend in the United States is for firms to

---

*Communication received from A. Parthasarathi.

specialize in these areas. Systems like single chip calculators and microprocessors are also specialities. The rapid growth of MOS LSI memories and its importance to the production of future generations of computers suggest that some immediate steps should be taken to establish the technology/ production as gestation time of such products is in the order of 2 or 3 years" ([27], pp. 470-471).

The plan also underlines the commitment to set up the Semiconductor Complex Ltd. (SCL) (see below section (a) on IC-producing firms), arguing that it should be done without delay in order to prevent substantial imports. The planned product mix of SCL was to include, <u>inter alia</u>, memories, calculator chips, shift registers and MOS microprocessors ([27], p. 473).

In 1982 a report was prepared by the Department of Electronics [26] as a result of a question raised in the Parliament of India as to why countries and areas such as China (Taiwan Province), Hong Kong, the Republic of Korea and Singapore had made phenomenal progress and marched ahead of India in the field of electronics. The response by the Department of Electronics stressed that any comparison with the countries mentioned must "recognize the fundamental difference between the objectives, philosophies and industrial framework which govern the development of industry in general in India on one hand and in the other countries and areas on the other. These are largely determined by the size, security environment, communication needs, economic structure and factor endowments, technological strategy and educational resources of each country" ([26], p. 1). It is therefore implied that part of any performance differences can be explained by the fact that the objectives are different in India as compared with the other countries. The Department of Electronics continues as follows:

> "We have adopted a strategy for development of the electronics industry which seeks:
>
> - to maximize the enormous resource which our huge domestic market constitutes;
>
> - to ensure indigenous production of as much as possible of electronic equipment for our strategic defence, communication, space and atomic energy needs;
>
> - to achieve technological self-reliance (not in terms of shutting out foreign technology, but in inducing it where necessary and then adapting and developing it appropriately while meeting the technological needs of our strategic electronic products maximally indigenously) to use the technological and industrial capacity built to meet domestic needs, as the springboard for our exports;
>
> - to maximize the dispersal of the electronics industry as widely as appropriate across our large country, thereby diffusing skills, employment, production and marketing;
>
> - to ensure that our public sector companies play a commanding role, particularly in sophisticated and professional sectors;

- to strive to realize an electronics industry that is well integrated as between its different subsectors, as also with the general industrial, agricultural, transportation and other sectors of the economy" ([26], pp. 1-2).

Thus, the objectives of Indian electronics policy were more complex than a mere maximization of the growth of output or exports. Self-reliance in strategic defence and other areas, as well as geographical dispersion of production across the continent and employment generation, took precedence over other objectives.

(c) Policy for the components industry

A new policy for the development of components was introduced in 1980, a policy which departs greatly from the general policy for the electronics industry. In 1981 this policy was implemented, with special emphasis being placed on the production of components that were internationally competitive in terms of both cost and quality. Restrictions on licensed capacity were removed and the free inflow of foreign technology was allowed [22], p. 26). The policy extract reproduced below is taken from [26].

"NOTE ON DEPARTMENT OF ELECTRONICS POLICY REGARDING ELECTRONICS COMPONENTS INDUSTRY

Plentiful availability of the numerous varieties of electronic components freely and at reasonable prices in India is considered to be the basic prerequisite for giving a boost to the production of electronic equipments and systems. Hence, Department of Electronics has decided on the approach outlined below for the development of electronic components industry:

1. Promoting/licensing/establishing components manufacture on a large and viable basis with a broad entrepreneur base would mean production somewhat in excess of purely domestic requirements. However, when the industry is grown on an internationally viable basis, immense export opportunities would be available.

2. Large capacities are required for economic viability on international scale as well as for ensuring product quality. This is technological compulsion due to the advent of automatic machinery. Accordingly the existing organized sector industries are encouraged to grow freely.

3. Looking to the demand position and the gestation periods, it is unlikely that the existing units would be able to meet the demand without substantial expansion and modernization. Therefore, fresh capacity creation is considered necessary. The capacity is being promoted only on an internationally viable basis. We take into account the domestic demand as also the export opportunities while examining the costs and technologies in any proposal.

4. Regarding foreign technology, Department of Electronics policy is to freely allow technology import in areas of modern types of components. There are inadequacies in technology

with the existing manufacturers, and very few approvals have been obtained for defence quality components.

5. Lower utilization of capacities observed in some cases now has been for reasons other than the demand constraints (generally managerial failures).

6. For the above reasons, components are unsuitable for production in the small-scale sector and both the Department of Electronics and DCSSI have been writing to all small-scale entrepreneurs for the past four/five years that it would be unwise to invest in components manufacture in the small-scale sector, and they would do so at their own risk since the Government may not be prepared to give protection."

Global techno-economic development has thus forced Indian policy-makers to speak in terms of exports, large capacities, economic viability on an international scale, technological compulsion, freely allowing technology imports and unsuitability for production in the small-scale sector. Domestic socio-economic objectives have therefore been overtaken by the international techno-economic imperative in the electronics components policy.

A few words should also be said about recent policy changes with regard to ICs. In November 1984 the Government of India announced a new and much more liberal policy for the manufacture and import of computers. The objectives included bringing the cost of domestically manufactured computers down to international levels. The policy also affects components, for example ICs. In particular, the policy document states the following: "... it is necessary that components should be available to manufacturers at as near international prices as possible"; "components which are not being manufactured in the country ... will be ... permitted to be imported at very low levels of import duty"; other "components will be protected from imports with sufficiently high protective duty".

At present, all types of ICs to be used in computers are subject to the open general licence, that is, no import licence is required, and a customs duty of only 25 per cent is applied.* With two exceptions, namely LSI circuits for watches and clocks, all LSI and VLSI circuits to be produced by SCL (the focal point of Indian production of LSI and VLSI circuits) are also on the open general licence list and carry a customs duty of 75 per cent. Imports of LSI circuits such as those produced by SCL for clocks, watches and computers would however be permitted only after clearance from the Department of Electronics.*

2. The components industry

A large variety of components used in the electronics industry are produced in India. Table 14 shows the output of components divided into four main categories. Of the total production of

---

*Communication received from A. Parthasarathi.

$223 million worth of components in 1982, $38 million were accounted for by semiconductor devices. About a dozen producers are engaged in the manufacture of semiconductor devices. Small signal devices and some power devices account for most of the total production of semiconductor devices in India, in figures, $32 million out of a total of $38 million in 1982. Local production of these devices largely satisfies the requirements of the Indian market ([30], p. 469). As may be seen from table 15, only a very small part of the production was accounted for by ICs. In 1982 total production of this type of semiconductor amounted to approximately $2.7 million. Production was raised to $4 million in 1984* and to more than $6 million in 1985.** The production of ICs is thus growing at a rapid pace now, but until recently it was small, like that of other semiconductors. The entire electronics components industry was also plagued by a number of problems, which will be discussed after describing the two vertically integrated IC producers in India.

Table 14. Production of components in India, 1982

Item	Production (millions of dollars)
Electron tubes	24
Semiconductor devices	38
Passive components	100
Electromechanical and other components	61
Total	223

Source: [30].

Table 15. Production of semiconductor devices in India, 1982

Item	Production (millions of rupees)
Small signal devices (diodes and transistors)	24
Power semiconductor devices	8
Integrated circuits	3
Rectifiers	1
Other semiconductor devices (solar cells, microwave devices etc.)	1
Total	37

Source: [30].

---

*Based on an interview with S. C. Mehta.

**Communication received from A. Parthasarathi.

(a) Firms producing integrated circuits

(i) Bharat Electronics Limited*

Bharat Electronics Ltd. (BEL) is a publicly owned company that was established in 1974. Its corporate mission is to promote self-reliance in the design, development and production of professional electronics equipment and components in India and to maintain the company's leadership in this field. It produces telecommunications equipment, including radio broadcasting and television transmitters, radar, underwater electronics, tank electronics and other professional equipment and systems, as well as semiconductor devices and electron tubes of both professional and consumer grades. Its present level of production is worth approximately $200 million and it employs nearly 18,000 people.

Within its components division BEL produces a range of ICs. Its production began in 1971 with a technology developed by an Indian research and development institute, the Tata Institute of Fundamental Research. At about the same time, BEL entered into a collaboration agreement with RCA for the production of ICs, using both bipolar and CMOS technologies. They produced 200,000 ICs in 1974/75, 400,000 in 1977, 2.2 million in 1984, and the current level of production is approximately 4 million ICs annually. The value of production was approximately $3 million in 1984 and $4 million in 1985. The bulk of the production consists of linear ICs, most of which are for the television market. Of the 52 different types of bipolar ICs and 16 different types of CMOS ICs in production, approximately 20 have been designed in-house, while the rest have been produced using an RCA design.

The BEL facility is vertically integrated in terms of both CAD and mask production. The minimum line width is in the 5-micron range for both bipolar and CMOS ICs. The ICs produced are in the MSI and lower end of the LSI level of complexity. About 600,000 hybrid ICs are also produced annually. This satisfies the entire BEL demand for hybrid ICs. Total investment by BEL for production facilities, including design, mask fabrication, assembly and testing, is $7 million.

In 1984, the plans of BEL were to "manufacture microprocessors and memory chips using RCA's technology in addition to several new circuits of MSI level under design in-house" ([30], p. 470). According to information received from the Chairman and Managing Director of BEL, their plans for the future lie especially in the area of ASICs, for which they plan to reduce the minimum line width to 2 or 3 microns.

---

*This section is based on the following: an interview conducted at BEL; written comments by the Chairman and Managing Director of BEL; [16]-[18]; and [30].

(ii) Semiconductor Complex Ltd*

The Government of India took the decision to set up a public sector company called the Semiconductor Complex Ltd. (SCL) to assume the task of "... leading the national effort in the manufacture, design and development of large-scale integrated circuits" ([16], p. 187). Plans to create SCL began in 1972. An initial $20 million (in 1976 dollars) were allocated to the project in 1976. A revised budget of approximately $50 million (in 1983 dollars) was approved in June 1983. There was considerable delay in the implementation of the project because of the difficulty of finding top management with industrial experience in this advanced field. The question of where (in which state of India) to locate the semi-conductor complex also took some time to resolve. From 1982, that is, a decade after the plans were initiated, the project has moved forward well.

SCL has entered into a collaboration agreement with American Microsystems Inc. for the purchase of 5-micron CMOS and NMOS silicon gate technology. American Microsystems Inc. is the largest firm in the field of custom-designed ICs. The agreement also gave SCL the option to purchase the more advanced 3-micron CMOS and NMOS technology within four years of the agreement becoming effective (April 1981). SCL, however, chose not to exercise the option to buy 3-micron technology from American Microsystems Inc., but to develop it in-house instead. As a result, SCL was able to introduce its own 3-micron technology into production in March 1986. The clock chip which SCL was already producing has been redesigned in 3-micron technology. This has resulted in a substantial reduction in the cost of manufacturing. SCL has achieved full vertical integration, from CAD and mask fabrication to wafer fabrication and packaging.

The SCL production line of LSI circuits currently includes telephone pulse diallers, clock chips, Rockwell 6502 microprocessors and associated peripheral interface chips. In the two years since production based on 5-micron technology was established, SCL supplied 10 semi-customized circuits and two fully customized circuits to various buyers of professional electronics devices. The Company is also designing a number of standard as well as customized circuits using its 3-micron technology. These include low-cost liquid-crystal-device watch circuits, calculator circuits, telephone speech-cum-tone ringer circuits and 128K CMOSROM. At the same time, SCL has begun to develop 2-micron technology, which is expected to be completed by the end of 1987. In addition to these research and development efforts within their own plant, SCL undertook a joint programme with American Microsystems Inc. for the development of 64K erasable programmable read-only memory. This joint development programme was to be completed by mid-1986. The total strength of design and process engineers in SCL is about 95. SCL has plans to establish a pilot line for a 1.25-micron process, a goal it expects to reach by 1989. Besides the initial capital outlay of $50 million, it invested approximately

---

*This section is based on information received from the Chairman and Managing Director of SCL.

$10 million in equipment in 1985/86 for 3- and 2-micron process development, and proposed to invest another $15 million during 1986/87 for electron beam mask-making operations and CAD.

SCL is responsible for supplying modules and electronic circuit blocks for all watches and clocks assembled in India. Another major product in the area of modules and subsystems being manufactured by SCL is an 8-bit microcomputer based on the Rockwell 6502 LSI chip. SCL has further plans to diversify its product line in modules and subsystems.

The current installed capacity of SCL corresponds to an annual production of 4.5 million LSI circuits. In later stages this capacity is planned to be increased to 9 and 20 million units yearly, in addition to 1.75 million modules and subsystems for electronic watches and other products. In 1982 the value of production was about $2 million, rising to about $7 million in 1985.

3. Evaluation of the electronic components industry of India

As regards the state of the electronic components industry in the early 1980s, the Department of Electronics ([25], p. 64) writes as follows:

> "The Indian electronic component industry is faced with many problems. Adequate investments have not been made nor was it allowed, capacity was restricted due to restrictive licensing conditions, outdated technologies are being used even with foreign collaboration due to restrictive conditions under which these were imported, ... inferior quality machinery has been imported and there is virtually no research and development for new product development ... as a result we are in a shortage situation. Quantity requirements have neither been met nor is the quality acceptable."

In addition, observers frequently note that the prices of Indian electronic components are far higher than those available on the international market. One observer ([29], p. 44) notes the following: "In India, however, prices of electronic components and finished assemblies tend to be three to ten times higher than the world market." A number of other writers make similar observations ([39] and [40]). The high costs can often be related to the low production volumes in India. It is common to have yearly volumes which are only a fraction of the output of international plants ([39], p. 74).

The development of technological capabilities in the IC field in India is supported by government-funded research institutes. The most important institutes, namely the Central Electronics Engineering Research Institute in Pilani and the Tata Institute of Fundamental Research in Bombay, started work with semiconductors in the mid-1960s. Later the various Indian Institutes of Technology also initiated work in this area ([37], p. 185).

As mentioned earlier, the bipolar (TTL 7400 series) technology was developed at the Tata Institute in 1971 and transferred to BEL in Bangalore. The TTL 7420 was the first IC made in India. A technology for an 8-micron CMOS metal gate circuit and a CMOS silicon gate technology have also been developed ([37], p. 189). No information is available as to whether the CMOS circuits have yet been put into production.

The Central Electronics Engineering Institute is a national laboratory under the Council of Scientific and Industrial Research, set up by the Government for advanced research and development in electronics. It initiated work in the IC field in 1969, primarily to develop linear and digital bipolar circuits. In 1976 the Institute initiated a programme on advanced technology for semiconductor devices, jointly supported by the United Nations Development Programme (UNDP) and the Government of India. The total investment in capital equipment has been about 50 million rupees (Rs). The basic interest of the Institute lies in the NMOS process, and some circuits of the complexity of LSI circuits have been developed ([30], p. 471; [37], p. 191). Whether any of its achievements have been followed up by commercial production is not known. Despite the work of the research and development institutes, substantial shortcomings remain, as reflected in the following observation:

> "An assessment of the current status of research and development and production in LSI in India shows that this activity has been funded at a subcritical level over the last decade and even this has been spread over several agencies without specific goals or requisite co-ordination" ([16], p. 155).

While it is beyond the scope of this paper to explain the relatively poor performance of the electronic components and, until recently, the IC industry, two factors that could be considered in an explanation should nevertheless be pointed out. These are the small local market for ICs and the poor links of the IC industry to the more demanding professional electronics industry, which is relatively large in India.

The market for ICs in India appears to be very small. Although complete data does not seem to exist, such a conclusion can nevertheless be drawn on the basis of the following information. In 1981/82 the content of LSI circuits in total production of electronics devices in India amounted to Rs 36.6 million. The market was divided among the various electronics industries as shown in table 16.

Table 16. Market for LSI circuits in India, 1981/82

Industry	Consumption of LSI circuits (millions of rupees)
Consumer electronics	10.0
Telecommunications systems	7.0
Computers	13.0
Space	4.6
Defence	2.0

<u>Source</u>: [16], p. 194.

There was no production of LSI circuits in India in 1981/82, but the total value of production of SSI and MSI circuits was approximately Rs 20 million. In addition, IC imports in 1981 amounted to Rs 108 million ([18], p. 45). IC exports were apparently negligible or nonexistent, hence the total market for ICs amounted to roughly Rs 120 million (approximately $13 million), one third of which was for large-scale integrated or VLSI circuits. In early 1985, it was suggested* that the value of the annual market for ICs was between $15 million and $19 million, from $5 million to $7 million of which were accounted for by custom-designed ICs. The share of custom-designed ICs in the total IC market in India is thus much higher than internationally, where the highest estimate is 20 per cent (see the discussion of the market for ICs in section B). The value of the Indian IC market in 1985 was estimated at $22 million,** which means that, although still rather small, it is growing rapidly.

The local production of SSI and MSI circuits at BEL is used mainly for the consumer goods market, for example in radios and television sets. In 1984, only 0.5 million of the 2.2 million ICs went to the professional electronics industry. Some of the IC production at SCL, clock chips for example, also goes to the consumer goods industry.

As was noted above, in 1984 the total value of the IC market in India was about $17 million, and Indian production amounted to $4 million. Let it be assumed that this production was equally divided between professional and consumer goods. Since the professional electronics industry accounted for a market of $11 million to $12 million,* it follows that imported ICs go mainly to that industry, as do all of the imported electronics components. It is estimated that in 1982 imports accounted for $125 million of a total market value of $343 million. For consumer-grade components, the market value was $187 million and local supply $167 million. For professional-grade components, the market value was $156 million, with imports accounting for $100 million ([25], p. 65).

The small size of the market for ICs in India has been a function of both the small electronics industry (which has begun to grow rapidly, however) and the low IC content of that industry. In 1981, for example, the IC content was only 0.5 per cent, whereas it was 10 per cent internationally in 1982 ([16], p. 165). Mehta and Varadan ([30], p. 471) suggest, <u>inter alia</u>, the following reasons for the low level of production of and demand for ICs in India:

(a) Most of the high-volume electronic systems made in India are based on discrete devices. For example, the overwhelming majority of telephone lines installed in India in 1982 were based on non-IC technology;

---

*Based on interview with S. C. Mehta.

**Communication received from A. Parthasarathi.

(b) A large variety of types of ICs make up an electronic system. The buyers tend to import the complete package of ICs, including those available indigenously. It has been argued* that "the main reason [for the low growth of the Indian IC industry] is that we have not been able to capture for local production more than about 30 per cent of the $22 million demand for ICs in 1985. Why? Largely because Government has not been able to design and enforce on the electronic equipment industry a strong standardization and variety minimization policy for ICs." Poor backward linkages from the professional electronics industry to the IC industry would be particularly important in explaining the poor growth of the IC industry, since the professional equipment industry is relatively strong in India;

(c) Low production volumes imply high prices, which in turn constrain demand.

Thus, the small market and the relatively large part of the market accounted for by the more demanding professional electronics industry may well have resulted in less incentive for investment in the IC industry in the past.

4. Analysis and conclusions

As was noted above in section (b) on Indian electronics policy, strong support was expressed in [27] for the establishment of SCL, with a product range including microprocessors and memories. In 1975 custom-designed ICs were rare, and it may be inferred that the planners envisaged a production unit that supplied standard ICs, as did most other producers in the world. After the agreement with American Microsystems Inc. on the process technology, which became effective in 1981, SCL also acquired the Rockwell 6502 microprocessor, which is a standard mass-production chip used, for example, in VIC 64 computers. In early 1984 Mehta and Varadan ([30], p. 470) wrote, furthermore, that the product mix of the SCL would consist of "... a broad range of standard LSI [circuits], including watch chips, calculator chips, telecom chips, memories, microprocessors and speech synthesizers". They add that "the range of products would also include custom LSI [circuits], modules and subassemblies based on LSI [circuits], gate arrays and standard cells". The basic strategy of SCL in the early 1980s therefore seems to have been regarded as one of concentrating on production of standard items, including mass-volume products such as micro-processors and memories. The plans for BEL also included the production of memories and microprocessors. In view of the development of the economics of production of standard ICs (see section B), the authors consider the emphasis placed on such ICs to have been premature. The Indian market for standard ICs was - and is - too small; the investment funds available were too limited to mass-produce VLSI circuits to international standards; and the cost of production in India would have been very high, as compared with international prices.

---

*Communication received from A. Parthasarathi.

A major rethinking of the basic strategy of the SCL appears to have taken place over the past few years, possibly as a result of the critique of the Indian electronic components industry made by the task force on large-scale and very large-scale integration, set up by the Department of Electronics. The task force argued very strongly in early 1984 [37] for the creation of a local capability for the production of integrated circuits for use in the telecommunications and defence equipment industry of the future. Particular emphasis was laid on the security of supply of custom-made ICs, and the needs of the defence industry were especially underlined. It has been emphasized that the export control restrictions of NATO makes local production of even standard LSI and VLSI circuits of strategic importance for the professional equipment industry.* The task force thus stated the following ([37], p. 156):

> "A local micro-electronics base, particularly with regard to custom and semi-custom circuits, is essential for future indigenous development of defense equipment within the country."

It has moreover been stressed that the strategic nature of local ASIC production refers not only to the supply of critical components for the defence industry, but also to its importance for the innovative capacity of the downstream industry.*

The current product range of the SCL, which has already developed 12 semi-customized or fully custom ICs and supplied them to the professional electronics industry, clearly suggests that the recommendations of the task force have been taken seriously. Specialization is the core of India's strategy on LSI and VLSI circuits. The Indian micro-electronics programme no longer covers memories and other bulk-manufactured LSI circuits. The basic strategy of India is that of "... mopping up all semi-custom and custom circuits our market needs for production by SCL (and partly by BEL) and buying multi-sourced standard LSI circuits on the world market, where they are not subject to export restrictions by NATO".*

Two further recent developments merit attention. First, SCL has set up a multi-user design centre for the Department of Electronics at Bangalore, and companies are using the CAD system of SCL to generate ASICs to meet their needs. These are subsequently processed into LSI circuits on the SCL wafer fabrication process line at Chandigarh [23]. Secondly, SCL is acting as a silicon foundry for BEL, ITI, Bharat Heavy Electricals Ltd. and the Central Electronics Engineering Institute laboratory at Pilani, taking their designs based on SCL design rules and processing them at Chandigarh. Hence the design capability in the field of ASICs exists not only at Chandigarh, but also in the design centre at Bangalore and among the major Indian firms within the electronics and electrical engineering industries. These designs are processed by SCL in addition to its own or licensed designs.

---

*Communication received from A. Parthasarathi.

The change that took place a few years ago in the Indian components policy and strategy on the production of LSI and VLSI circuits in SCL and partly in BEL, a change that consisted in placing greater emphasis on ASICs than on standard ICs, seems to have been a correct step. It was based on the following considerations:

(a) The changes in the economics of standard IC production characterized by growing barriers to entry and economies of scale;

(b) The small local market for standard VLSI circuits and the not insignificant local market for ASICs;

(c) The need for a secure supply of components, mainly ASICs, to the telecommunications and defence industries;

(d) The strategic importance of having a local ASIC producer for professional electronics industries other than the telecommunications and defence industries.

In pursuing its new strategy, given the capital available to it and the development of a minimum line width of 3 microns, SCL is well in step with the international industry producing ASICs.

E. A comparison of the integrated circuit industries of India and the Republic of Korea

In this final section, the approaches of the IC industries in India and the Republic of Korea, seen from an international perspective, will be compared, with special attention being given to the determinants of the divergence in approaches. Some of the essential characteristics of the four firms that have been discussed, namely Samsung Semiconductor Ltd. and Gold Star Semiconductor Ltd. in the Republic of Korea, and Bharat Electronics Ltd. and Semiconductor Complex Ltd. in India, are summarized in table 17.

The first thing to note is that both firms in the Republic of Korea belong to large conglomerates. The Indian firms, in contrast, are purely electronics firms. Another difference is that unlike the firms in the Republic of Korea, the Indian firms are State-owned. In terms of the output of ICs, the firms in the Republic of Korea are substantially larger than the Indian firms. The product ranges of the former are also wider. As for the technological levels, while the firms in the Republic of Korea are strong in dynamic memories, SCL is strong in telecommunications circuits, specialized industrial products like erasable programmable read-only memories, and customized and semi-customized circuits for strategic applications. In terms of the sources of technology, all the firms produce with predominantly licensed technology. However, Samsung appears to have relied on its own technology for many of its simpler ICs directed towards the consumer goods market. Samsung also claims to have done much of the process development for its DRAMs. SCL has also developed and put into industrial production its own 3-micron LSI CMOS process, which is well in line with other ASIC producers in the world, and has

Table 17. Some characteristics of four IC-producing firms in the Republic of Korea and India

Firm and country	Type of ownership	Approximate value of output of ICs a/ (millions of dollars)	Approximate number of design engineers	Product range	Origin of technology	Investment in production and design capacity
Samsung (Republic of Korea)	Conglomerate	14 (1983)	100	Linear and CMOS ICs for consumer goods; 64K DRAM; customized ICs for the telecommunications industry; planned introduction of 16K SRAM and 256K ROM.	Mainly own consumer goods; technology from United States and Japan for memories.	$275 invested by 1986 and total of $487 million planned to be spent on semiconductor plant investment in 1985-1987; $84 million planned to be invested in research and development during the same period.
Gold Star (Republic of Korea)	Conglomerate	13 (1983)	100 designers and process engineers	Linear SSI circuits and MSI circuits for consumer goods; pilot manufacturing of 64K DRAM; microprocessor production started, gate-array technology received and production planned by end of 1984; small-scale production of customized ICs.	American Telephone and Telegraph for 64K DRAM; Zilog for microprocessors and LSI circuit logic for gate array.	$94 million invested by 1986 and total of $192 million planned to be spent on semiconductor plant investment in 1985-1987; $15 millio planned to be spent on research and development during the same period.
Semi-conductor Complex Ltd. (India)	State	1.5 (1985)	95 designers and process engineers	CMOS and NMOS; b/ LSI and VLSI circuits of 5-micron line width; products include telephone pulse diallers, clock and watch circuits, microprocessors and semi-customized and customized circuits; plans for ROMs and EPROMs. c/	Licences from United States firms American Microsystems Inc. and Rockwell and own technology.	$59 million invested by 1985 and $15 million planned for 1986-1987.
Bharat Electronics Ltd. (India)	State	4 (1985)	35-40 designers	CMOS and bipolar SSI circuits and MSI circuits of down to 5-micron line width; products include ICs for black and white and colour television sets and military-grade ICs for military equipment made by BEL.	Radio Corporation of America and own technology.	$7 million invested by 1985.

a/ Year indicated in parentheses.

b/ n-channel metal oxide semiconductor.

c/ Erasable programmable read-only memory.

designed 10 semi-customized and two fully customized ICs. Finally, the investment in production capacity is very much higher in the Republic of Korea than in India.

At this stage it is appropriate to recall what was said in section B about barriers to entry. It was concluded that the barriers to entry for the production of standard ICs have increased rapidly during the last decade. The cost of a state-of-the-art standard IC factory is currently $200 million. This is mainly because of technical change in IC processing. Research and development costs have also risen. The barriers to entry for custom-designed IC production are much lower. A factory for manufacturing ASICs (that is, semi-customized or fully customized ICs) may currently cost as little as $25 million.

The IC industries in both India and the Republic of Korea are striving to include more advanced products in their product ranges. While the product technology relating to the microprocessor produced by SCL (the Rockwell 6502) is dated, the company's LSI and VLSI telecommunications circuits, for example pulse dialers and codets, are state-of-the-art. As for the firms in the Republic of Korea, they are relatively weak in telecommunications ICs but strong with regard to memories. A further difference is the scale of investment made in the production of LSI and VLSI circuits. The investments of Samsung, for example, are in line with those made internationally, while those of SCL are at, or below, the lower limit for standard LSI and VLSI circuits. However, SCL investment is internationally comparable to that of plants that make application-specific LSI circuits.

In terms of the different research and development strategies referred to in section B, the Indian firms are clearly choosing the "lagging behind" approach with respect to ICs introduced in the United States and Japan having adopted, for example, the Rockwell 6502 microprocessor. Samsung is opting for the "leading-edge" strategy, while Gold Star seems to have adopted a "wait-and-see" strategy, relying on a continuous dependence on the import of technology from partners abroad. The difference in research and development spending between Samsung and Gold Star clearly reflects the different strategies pursued. Admittedly, the risk involved with choosing a strategy like that of Samsung, with an emphasis on 64K DRAM and 256K DRAM production, are substantial, but so are the potential benefits. This issue will now be further discussed.

As was noted in section B, the market situation with regard to advanced DRAMs is very unstable. The price of 64K DRAMS dropped from $50 to $0.50 in five years. Something similar appears to be happening with the 256K DRAMs, which, moreover, are expected to replace 64K DRAMs very rapidly. Already in 1984, Hitachi decreased its output of 64K DRAM, while stepping up that of 256K DRAM. The picture was not, however, uniform; other firms were simultaneously increasing their production of 64K DRAM ([44], p. 41). If and when many companies switch over wholeheartedly to 256K DRAM, it is likely that the 64K market will be greatly affected. If that happened in 1986 - as many analysts expected - the producers of 64K DRAM in the

Republic of Korea would certainly not be able to recover their investments of $120 million, and the whole effort might prove to have been an economic failure. Indeed, one source has suggested that in mid-1985 the international price of 64K DRAM was already below the break-even price of producers in the Republic of Korea ([3], p. 61).

Hence, it is clear that the Samsung effort is extremely risky. If the 64K venture fails, Samsung may, however, hope to be an earlier starter in the 256 K race - thanks to their experience with the 64K DRAM. The swift move of Samsung to 256K DRAM may suggest that the firm has benefitted by this experience. But in a later race the one-megabit DRAM may still be waiting as an unpleasant surprise behind a bend. The risks at stake are indicated by the fact that Inmos of the United Kingdom announced in July 1985 that it would cease production of DRAMs and obtain them from Japan and the Republic of Korea in future ([2], p. 7). On the other hand, Samsung may come out as a winner and the Republic of Korea would then be among the very few countries in the world to be competing successfully in this line of business. It must be pointed out here that there is a considerable debate in the Republic of Korea regarding the social usefulness of Samsung's strategy ([3] and [5]).

In section B, in the discussion of barriers to entry, the global IC industry was divided into the following four subgroups: large producers of standard ICs; smaller producers of ASICs; specialized design houses; and specialized silicon foundries. Samsung Semiconductor Ltd. in the Republic of Korea has clearly chosen to enter the first subgroup. Although extremely risky, it is, in principle, a viable strategy, provided the large amount of capital needed is available and the objective is mainly to export ICs. Samsung may however fail, and it will then turn out to be a very costly adventure for the Samsung conglomerate and for the economy of the Republic of Korea. On the other hand, a success would mean that the Republic of Korea will be more advanced than most European countries with regard to standard IC production.

From a national point of view, it would be unwise for another company in the Republic of Korea to follow the same high-risk strategy. It seems more sensible for Gold Star, which appears to be in the process of choosing between the first and second of the above-mentioned strategies, to specialize in the production of ASICs, since Gold Star is not as far ahead as Samsung in any case. Such a strategy would also considerably reduce fixed capital requirements.

An ASIC strategy would first require the identification of the IC content of various electronics products, such as television sets, videotape recorders and defence equipment, to be domestically produced. Thereafter, research and development efforts should be geared towards custom-designing ICs with the required characteristics. The final objective would be to produce electronics products competitively, and here the links between IC producers and IC users would be crucial. Such a strategy would be much less risky not only because capital requirements would be smaller, but also because output would be geared mainly to the domestic market, at least in the initial stages. It would also make producers of electronic products in the Republic of Korea less vulnerable, thanks to decreased dependency on imports of ICs that are strategic for the electronics industry.

Indian policy vis-à-vis the IC industry and the strategy of SCL seem to have shifted in the 1980s in favour of local production predominantly geared towards ASICs. Specialized design houses are also being built up. The ASICs designed there are subsequently processed by SCL, which in this case acts as a silicon foundry. In the authors' view, the same pattern should be developed in the Republic of Korea. It is, however, doubtful whether Gold Star could be the national champion in this case, since it is one of the largest conglomerates in the Republic of Korea. This means that firms within the Gold Star conglomerate compete in many final markets with other conglomerates. A firm may not like to transfer its product knowledge to a competitor to the extent required when an ASIC is to be designed.

The determinants of the widely diverging approaches of the two countries are many and complex. Development objectives, in particular, probably play an essential role. The Indian objectives include self-reliance and promoting applications of LSI and VLSI circuits in distinctively Indian end-products, for example agro-electronic equipment such as milk and grain analysers, rural radio communications equipment, rural telephone exchanges and hydro-meteorological systems, all of which call for greater emphasis on customized and semi-customized ICs. These objectives, towards which progress is being made, have surely affected Indian policy towards the IC industries and its implementation. Some other determinants will be discussed below.

One determinant is the enormous difference in the size of the domestic markets for ICs in the two countries. While that of India was about $22 million, that of the Republic of Korea approached $200 million in 1983. Such a difference cannot be explained merely by the much larger production of electronics products in the Republic of Korea; the IC content of production in the Republic of Korea must also be much higher than that of India. In particular, demand for colour television sets and telecommunications equipment plays an important role in generating a substantially higher demand for ICs in the Republic of Korea than in India. In 1983 the size of the IC market in the Republic of Korea was close to that of Italy ($211 million) and of France ($332 million) ([42], p. 42). The existence of a large domestic market does not necessarily mean that firms in the Republic of Korea should themselves seek to meet all its needs. Nevertheless, the development of a local IC industry was seen as necessary in order to break the dependence on Japanese suppliers and enable firms in the Republic of Korea to become competitive in the electronics industry. This applied in particular to consumer electronics products such as video-tape recorders and televisions sets. In contrast, the Indian market for

ICs lies predominantly in the more advanced professional electronics area. However, the lower content of LSI and VLSI circuits in the current generation of advanced professional products has reduced the size of the market for such circuits, thus making it less attractive, and perhaps even unnecessary, to manufacture them.

The fact that the local market stimulated efforts in the 1980s to produce ICs in the Republic of Korea demonstrates the importance of local-market-oriented strategies, even though the bulk of demand for ICs in that country is still met by imports.

The structure of the electronics industry, including the IC industry, is seen as another important determinant of the different approaches. For the Indian industry, the competitive pressure in relation to exports and, at least according to Mody [31], in relation to the local market, is less strong than in the industry in the Republic of Korea. This affects the behaviour of both the IC industry and the electronics equipment industry in general. The behaviour of the latter industry subsequently influences the size of the domestic market for ICs.

Another aspect of the institutional framework is the ownership of the IC firm and the associated difference in the decision-making process. It has been noted that the firms in the Republic of Korea belong to conglomerates, while the Indian firms are State-owned. In principle, the Government of India could act, in resource allocation matters, on the same scale as a conglomerate, but there is apparently a difference in the risk propensity between, for example, the Samsung conglomerate and the Government of India.

The Government of the Republic of Korea uses the credit instrument to shape the industrial structure. Especially in a fast-changing industry, where barriers to entry are rapidly increasing, firms may need not only protection in order to mature but also access to the necessary means of production, in particular access to a large amount of high-risk capital. Despite the meagre evidence of the credit instrument's being important in the historical development of the IC industry - Gaule [20], however, argues that it is - the new semiconductor programme of the Government of the Republic of Korea, although not implemented as planned [21], did provide for the allocation of around $350 million to this industry. It is illustrative to compare this with the scale of intervention in the countries of the Organisation for Economic Co-operation and Development (OECD). As may be seen from table 18, the largest single programme, although it involves only research and development assistance, is the European Esprit programme, which receives $744 million. The programme of the Republic of Korea was thus on a very large scale, which indicates the willingness of the Government to intervene through its credit policies. In India, credit is practically not used as an instrument for industrial policy purposes, although companies such as SCL and BEL naturally receive funds from the State.

As mentioned in the respective sections on India and the Republic of Korea, there are in both countries government research

Table 18. Government research and development assistance in the microelectronics field in OECD countries

Country or grouping	Date	Project	Amount (millions of dollars)	Comments
Australia	1983-1984	CSIRO a/ research	0.6	
Canada	1981	Gallium arsenide devices	1.7	
European Communities	1983-1984	Esprit c/ pilot project	11.4	
	1982-1985	Microelectronics programme	32.0	Share of the European Communities
	1984-1989	Esprit	744.0	Share of the European Communities
Finland	1982-1985	CMOS progress technology	7.0	Funds for equipment and salaries
France	1982-1986	Second Components Plan	487.0	
Germany, Federal Republic of	1974-1978	BMFT d/ electronic components	157.0	Research and development assistance to industry and institutions
	1981-1982	BMFT electronic components	110.0	
	1981-1984	VDI e/ research and development	0.9	
	1984-1988	Submicron technology	196.0	
Japan	1975-1981	LSI circuits for computers, telecommunications and microwave devices	180.0	
	1976-1979	VLSI circuits	121.2	Repayment required
	1980-1991	Optoelectronics	77.5	Consignment payment (no refunding)

continued

Table 18 (continued)

Country or grouping	Date	Project	Amount (millions of dollars)	Comments
	1982-1990	Supercomputer	92.3	
	1982-1989	New function elements	100.4	
Sweden	1980-1985	National Board for Technical Development	47.3	Grants to technical schools
United Kingdom	1983-1988	Advanced information technology programme	308.5	
United States	1978-1984	VHSIC b/ programme, phase 1	341.4	
	1978-1982	Non-VHSIC research and development	200.5	
	1985-1989	VHSIC programme, phase 2	340.3	

Source: [47], p. 18.

Note: Data are not strictly comparable for the following reasons: assistance may be in the form of loans or grants; it may be made directly to firms or to universities and technical institutions; and some projects are also part of larger programmes and include other elements that may be of only indirect relevance to IC research and development (for example, software, CAD and computer architecture). Levels of funding for projects after 1983 are subject to change. Data are also incomplete because details of research and development programmes of all countries are not known.

a/ CSIRO: Commonwealth Scientific and Industrial Research Organization.

b/ VHSIC: Very-high-speed integrated circuits.

c/ ESPRIT: European Strategic Programme for Research and Development in Information Technologies.

d/ BMFT: Ministry of Technology and Research (Federal Republic of Germany).

e/ VDI: Association of German Engineers Technology Centre (Federal Republic of Germany).

institutes involved in work on ICs, for example KIET in the Republic of Korea and the Tata Institute of Fundamental Research in India. It is quite difficult to evaluate in specific terms what impact they have had upon technical developments in the two countries. However, there are several examples where it has been shown that KIET has developed a number of ICs in collaboration with industry, for example linear ICs for Korea Electronics Corporation and videotape-recorder ICs for Gold Star and Samsung. Projects developed for industry have been partly Government-financed. KIET may also have played an important catalytic role by demonstrating that sophisticated ICs could be successfully made in the Republic of Korea. This may have given firms the confidence to enter IC production. However, at present all the big firms acquire most of their IC technology from abroad, and the technological capabilities of the domestic firms now exceed those of KIET. Hence the future role of KIET may lie increasingly in basic research and not so much in the acquisition of manufacturing capability ([31], pp. 72-73). The fact that in September 1984 KIET was said to be in the process of selling its entire production facility may be the result of such a reorientation. The Government Research and Development Institutes in India have had much less of an impact upon industrial production. The only technology known to have been transferred to the productive sector is the simple bipolar IC design transferred from the Tata Institute to BEL in 1971. Although the research and development institutes working on LSI and VLSI circuits have probably played some educational role, the relationship between resource input and output, of relevance for the productive sector, seems to have been unsatisfactory.

Bibliography

1. Bank of Korea. Input/output tables 1980. Seoul, Bank of Korea, 1983.

2. Boiling oil for chip makers. Financial Times, 8 July 1985.

3. Business Korea (Seoul), August 1984.

4. _____ September 1984.

5. August 1985.

6. Dagens Industri (Stockholm), 14 August 1985.

7. Edquist, C. and S. Jacobsson. Automation in engineering of India and Republic of Korea against the background of experience of some OECD countries. Economic and political weekly (Bombay) 20:15, 13 April 1985.

8. _____ A macro perspective of the Korean and Indian engineering industries. Lund, Sweden, Research Policy Institute, December 1985. Mimeographed.

9. _____ Technical change and patterns of specialization in the capital goods industries of Cuba, India and the Republic of Korea: a project description. Lund, Sweden, Research Policy Institute, 1982.

10. _____ The diffusion of electronics technology in the capital goods sector in the industrialized countries. Geneva, United Nations Conference on Trade and Development, 1985. (UNCTAD/TT/65).

11. _____ The production of heat exchangers in India and the Republic of Korea. Lund, Sweden, Research Policy Institute, 1985.
Mimeographed.

12. _____ The production of hydraulic excavators and machining centres in India and the Republic of Korea: state policies, firm performance and firm strategies. Economic and political weekly (Bombay), November 1985.

13. _____ The production of submersible pumps in India and the Republic of Korea. Lund, Sweden, Research Policy Institute, December 1985.
Mimeographed.

14. Edquist, C., S. Jacobsson and S. H. Lee. The diffusion of electronically controlled capital goods in the OECD countries and implications for the Korean engineering industry. Lund, Sweden, Research Policy Institute, November 1985.
Mimeographed.

15. Electronics Industries Association of Korea (EIAK). Statistics of electronics and electrical industries. Seoul, 1984.

16. Electronics information and planning (New Delhi), January 1984.

17. _____ May 1984.

18. _____ October 1984.

19. _____ September 1985.

20. Gaule, A. La montée de la Corée dans l'electronique mondiale: vers un nouveau défi? Grenoble, Institut de recherche économique et de planification du développement, juin 1984.

21. Hyun, Kim Joon. The structure of the semiconductor industry and development policy. Seoul, Korea Institute of Economics and Technology, 1985.
In Korean.

22. India. Department of Electronics. Annual report 1981-82. New Delhi, 1982.

23. _____ Annual report 1984-85. New Delhi, 1985.

24. _____ Annual report 1985-86. New Delhi, 1986

25. _____ Draft report of the Seventh Plan Working Group on Electronics Industry. New Delhi, 1984.

26. _____ Electronics in India in comparison with electronics in South Korea, Taiwan, Singapore and Hong Kong. New Delhi, November 1982.

27. _____ Electronics Commission. Perspective report on electronics in India. New Delhi, June 1975.

28. International Herald Tribune, 22 July 1985.

29. Malgavkar, P. D. Technologies for accelerated industrial growth. New Delhi, Centre for Policy Research, 1984. Mimeographed.

30. Mehta, S. C. and G. S. Varadan. State-of-the-art of microelectronics in India. Electronics information and planning (New Delhi) 11:8, May 1984.

31. Mody, A. Comparative study of electronics in India and Korea. Washington, D.C., World Bank, 1984. Mimeographed.

32. Morehouse, W. and R. Chopra. Chicken and egg: electronics and social change in India. Lund, Sweden, Research Policy Institute, 1983. (Technology and Culture Occasional Report Series No. 10).

33. Organisation for Economic Co-operation and Development. Trade in high-technology products. The semiconductor industry: industrial structure and government policies. Paris, April 1984.

34. Penn, M. G. Impact and opportunities for application-specific integrated circuits (ASICs). IEE proceedings, 132:2, March/April 1985.

35. Port, O. For chipmakers, national boundaries begin to blur. Business weekly (New York) pp. 86-87, 6 May 1985.

36. Rao, A. S. and A. Parthasarathi. The Indian electronics industry. National Electronics Council review (London), July-September 1968.

37. Report of the Task Force on LSI/VLSI Technology. Electronics Information and Planning (New Delhi) 11:4, January 1984.

38. Samsung Group annual report 1983. Seoul.

39. Sarnot, S. L. Electronic components industry: perspective for growth in the 80s. Electronics for you (New Delhi), annual number, 1983.

40. Sigurdson, J. and P. Bhargava. The challenges of the electronics industry in China and India. In Technological trends and challenges in electronics. S. Jacobsson and J. Sigurdson, eds. Lund, Sweden, Research Policy Institute, 1983.

41. Strauss, William I., ed. Status 1984: a report on the Integrated Circuit Engineering Corporation. Scottsdale, Arizona, 1984.

42. van Tulder, Rob and Eric van Empel. European multinationals in the semiconductor industry: their position in microprocessors - a pilot study. University of Amsterdam, October 1984.

43. Transnational Corporations in the International Semiconductor Industry (United Nations publication, Sales No. E.86.II.A.1).

44. United Nations Industrial Development Organization. Microelectronics monitor (Vienna), 10/11, April-September 1984.

45. _____ State-of-the-art series on microelectronics: No. 3 - Republic of Korea [Prepared by K. Chou]. (UNIDO/IS.490, October 1984).

46. _____ The engineering industry of the Republic of Korea [Prepared by C. Edquist and S. Jacobsson] 1985. 38 p.

47. Ypsilanti, Dimitri. The semiconductor industry. OECD observer (Paris), No. 132, 14-20 January 1985.

EMPLOYMENT LINKAGES IN BANGLADESH INDUSTRIES

Dilip Kumar Roy*

Introduction

The analysis of employment linkages is important for least developed countries such as Bangladesh, where unemployment, under-employment and poverty are inseparable [1]. The linkage concept is based on industrial interdependence,** and employment linkages in different industries have potential implications for an industrialization strategy that stresses employment growth.

The purpose of this study is to determine the relative importance of individual industries by analysing the employment effects of interindustry linkages. Total employment linkages in each industry will be measured from the Hirschman production linkages and by the hypothetical extraction method following Meller and Marfán [2]. Backward and forward linkages are regarded by Hirschman [3] as production linkages when referring to the effect of a one-unit increase in the autonomous portion of final demand on the level of production in each industry.

The sources of data for this study and the definitions used are indicated in the annex.

A. Measurement of total backward and forward employment linkages

1. Hirschman's production linkages

The column sum of the Leontief inverse matrix represents direct and indirect backward production linkages. But the raw sum of the Leontief inverse matrix does not provide a measure of forward linkages because forward linkage is actually being measured on the strength of backward linkage coefficients. Jones [4] has suggested

---

*Bangladesh Institue of Development Studies, Adamjee Court, Motijheel C.A., Dacca-2. The author is a research fellow at the Bangladesh Institute of Development Studies. The paper is partly adapted from chapter 7 of the author's doctoral dissertation submitted at the University of Antwerp, Belgium. The helpful comments of P.K.M. Tharakan, L. Berlage and R. Van Straelen are gratefully acknowledged.

**The measurement of interdependencies among industries indicates the capacity of a given industry to stimulate other industries. The linkage concept is based on industrial interdependence.

ways to measure forward linkage, a problem that has also been dealt with by Hirschman.* Forward linkage is derived from the output inverse matrix as distinct from the traditional Leontief input inverse. Briefly, the latter is based on a matrix of technical input coefficients while the former uses technical output coefficients. The element of technical output coefficient matrix (B) is the ratio of intermediate sales to total sales including final demand, whereas the element of technical input coefficient matrix (A) is the intermediate input as a share of total input including value added.

Let is be assumed that

F	=	intermediate input flow matrix (n x n)
X	=	total output flow vector (n x 1)
[X']	=	diagonal matrix (n x n) whose diagonal elements are those of the X vector
I	=	identity matrix
i	=	unity column vector

Then,

A	=	$F [X']^{-1}$	=	input coefficient matrix or technical coefficient matrix of Leontief system	(1)
B	=	$[X']^{-1}F$	=	output coefficient matrix	(2)
R	=	$(I-A)^{-1}$	=	input inverse or Leontief inverse matrix	(3)
W	=	$(I-B)^{-1}$	=	output inverse matrix	(4)
FL	=	W_i	=	direct and indirect forward linkage vector	(5)

The R_{ij} element of R is the increase in output of industry i to supply the inputs required for a unit of final demand in industry j. The W_{ij} element of W is the increase in output of industry j required to utilize the increased output in industry i. The sum of row i of W is the increase in total output of the system required to utilize the increased output from an initial unit of primary input in industry i, whereas the sum of column j of R is the increase in total output of the system required to supply inputs for an initial unit increase in industry j. Therefore, the row sum

---

*The paper by L. P. Jones has become noteworthy for solving the problem of how to measure total (direct plus indirect) forward linkage effects. See Hirschman [3], pp. 67-98.

of the output inverse indicates forward linkages while the column sum of the input inverse measures backward linkages. R gives the effect of expansion on suppliers, while W gives the impact on user industries. The W matrix starts at the beginning of the production process, and traces the effect forward through the system. The R matrix starts at the end of the production process with an increase in final demand and traces the effect backward through the system. For the economy as a whole, total forward linkages equal backward linkages when both are weighted by the value of output, and this would obviously involve double counting of causal linkages. For an individual industry, when the output of both suppliers and users expands, then forward and backward linkages are effective and total linkages represent maximum potential causal linkages.

2. Measurement of employment linkages

The total employment linkages of an industry j (STL_j) are expressed as the sum of backward and forward employment linkages of that industry.

$$STL_j = BL_j + FL_j \qquad (6)$$

(a) Backward employment linkage

Backward employment linkages (BL) correspond to total (direct and indirect) labour requirements per unit of output to satisfy final demand. It is expressed as

$$BL = [BL_j] = [\ ]_{1xn}[I-A]^{-1} \qquad (7)$$

Where $[BL_j]$ = column vector of backward linkages for n industries

$[\ ]$ = row vector of direct labour coefficients for n industries

and $[I-A]^{-1}$ = Leontief inverse matrix

(b) Forward employment linkage

The index of forward employment linkage (direct plus indirect) has been measured from Jones' index of forward linkage. The total forward employment linkage (FL) can be formulated as

$$FL = [FL_j] = W[\ ] \qquad (8)$$

where $W = (I-B)^{-1}$ = output inverse matrix

$[\ ]_{nx1}$ = column vector of direct labour coefficients

$[FL_j]$ = row vector of forward linkages for n industries

3. Measurement of total employment linkages by means of the hypothetical extraction method

This approach was suggested originally by Siegfried Schultz [5] to determine the significance of each industry and also to identify key industries, numerically comparing output levels which may be produced through the total linkage effect. Meller and Marfán [2] have used a similar approach to measure total employment linkages, which include both backward and forward employment linkages.

In this methodology, measurement of linkages consisted in defining them as the losses in total output (employment) resulting from the hypothetical extraction of a given industry. That is, if the intermediate and final requirements of the output of an industry are removed, for example, replaced by imports, and ongoing economic activities adjust to this change, then the total output and employment linkages of the removed industry equal the sum of all the output and employment changes of the economy as a whole.

Let it be assumed that industry X is removed from the economy, that is, the output of industry X is replaced by imports. The industry no longer maintains backward and forward linkages because it does not buy or sell any inputs to the remaining industries. At the same time, the total employment effect of the remaining industries is diminished because fewer domestically produced inputs are being bought and sold. This reduction is related to the inputs that were previously bought and sold by industry X, and affects the number of jobs.

In short, the removal of an industry reduces forward and backward linkages of the remaining industries and so reduces their employment multiplier effects. The computation of this reduction in employment provides the total backward-plus-forward employment linkages of the industry removed, which are called total employment linkages. Symbolically, the total employment linkages of an industry j is expressed by

$$HTL_j \quad = \quad [l] \, (I-A)^{-1} i \; - \; [l_j^*] \, (I-A_j^*)^{-1} i \qquad (9)$$

where HTL_j in equation (9) is a non-weighted measurement that assumes all final outputs to be unities.

$[A_j^*]$	=	technological matrix of (n-1) (n-1) obtained by removing from A the row and column of a given sector j
$[l_j^*]$	=	director labour coefficients vector of (n-1)x1, obtained by extracting element j of (?).
i	=	sum vector formed by "ones".

One can subtract employment linkages of an industry (BL_j or FL_j) from total employment linkages (HTL_j) measured by equation (9), to obtain the corresponding forward or backward linkages of that industry. But it is clearly an arbitrary way of measuring either forward or backward employment linkages.

B. Methodology for identifying key employment industries

1. Concept of key industry

The selection of key industries* involves the determination of industries which are assumed to bring, through backward and forward employment linkages, a greater-than-average impact upon an economy. The identification of key industries should be explicitly related t policy preferences, which are assumed to be oriented towards ; iuctive employment generation. Conflict between employment and output objectives may not appear if the identified industries are efficient.

The selection of key industries should not conflict with the condition that supply equals demand, which is the underlying condition of the input-output framework. In the input-output model, the entire product has to be consumed by other industries as intermediate inputs and by final demand. Further expansion of the industries will depend on whether there is adequate demand for their products in both the domestic and international markets. A country should export those commodities which make intensive use of its abundant factors of production. In other words, an increase in exports from countries which have a relative abundance of labour and a scarcity of capital tends to favour labour-intensive industries (with high backward employment linkages). The average consumption level of low-income groups will be increased when demand for domestically produced manufactures from industries with high backward employment linkages is increased. Otherwise, there should be a limit to the growth of an industry, no matter how high its linkage index. However, the author's study of the evidence [6] tends to indicate that exports of manufactures and demand for domestically produced manufactures are labour-absorbing.

---

*There is also a view that key industries may be defined in other ways. An industry i is key for industry j if the production of j is technically dependent on the products of i (for example, iron ore is key for steel). The point may be raised whether the inputs used are abundantly available as natural resources in the country concerned, a circumstance that may produce a different impact on forward and backward linkages. The aim of this study is to identify key employment sectors based on higher employment linkages through the use of an input-output model which assumes, among other things, that production coefficients are fixed. This means that the measurement of total employment linkages uses the fixed input-outut relationship and thus takes into account the importance of input-supplying industries.

One industry grows differently from other industries precisely because of existing differences in linkage indices, and such growth differentiation by industry will not create imbalances within the input-output framework if the entire product is consumed as intermediate inputs and by final demand.

2. Selection of key employment industries

The value of rank correlation coefficients between backward and forward employment linkages of manufacturing industries is 0.60 (t = 3.13), which suggests that the ranking of industries by backward and forward employment linkages is not completely different from sector to sector. It is argued [4] that for an individual industry, both suppliers and users are stimulated to make forward and backward linkages effective and to develop the maximum potential causal linkages.

Backward linkages are more likely to be causal since the increased demand for intermediate inputs (backward linkages) is more effective than the supply (forward linkages). But in the absence of response from industries with high forward linkages, there would be constraints on the users of inputs. For example, electricity has relatively high forward linkages, but these are not causal since expansion is better viewed as the result of demand generated by backward linkages of the users. Backward employment linkages and total employment linkages will therefore be used for the selection of key employment industries. The rank order of total employment linkages and the average of backward and forward employment linkages, as well as the linkage coefficients as defined below, will obviously be the same.

Linkage coefficients corresponding to backward and total linkages have been computed in order to specify the criteria used in selecting key industries. A key industry for employment generation will have a backward linkage coefficient and either of its total linkage coefficients (STLC or HLTC as defined below) simultaneously greater than one.

(a) Backward linkage coefficients

Backward linkage coefficients are obtained by computing the relative value of the backward employment linkage of each industry with respect to the simple average of backward linkage effects of all industries. The simple average has been scaled down to one.

In mathematical notation, backward linkage coefficients for an industry j is expressed as

$$BLC_j = \frac{BL_j}{(\sum_{j=1}^{n} BL_j)/n} \qquad (10)$$

If industry j has a value of BLC_j greater than one, then it has more backward employment linkages than the average of the total manufacturing sector.

(b) Total linkage coefficients

Total linkage coefficients (STLC and HTLC) are obtained in the same way as backward linkage coefficients. Again, industries with total linkage coefficients greater than one have more total employment linkages than the average of the total manufacturing sector.

Symbolically, $$STLC_j = \frac{STL_j}{(\sum_{j=1}^{n} STL_j)/n} \quad \text{for industry } j \qquad (11)$$

and $$HTLC_j = \frac{HTL_j}{(\sum_{j=1}^{n} HTL_j)/n} \quad \text{for industry } j \qquad (12)$$

If industry j has a value either of $STLC_j$ or $HTLC_j$ greater than one, it has more total employment linkages than the average of the total manufacturing sector.

C. Empirical results

As previously stated, employment linkages are derived by relating Hirschman linkages to employment instead of to production. Table 1 gives values of total employment linkages by summation (STL), total employment linkages based on the hypothetical method (HTL) and backward employment linkages by industrial branch. Key employment industries are those having more employment linkages than the average for manufacturing industry. If output increases by one unit in each of the manufacturing industries, the key industries for employment generation will be those that show the most employment linkages in that unit. As noted earlier, key industries are those for which values of backward employment linkage coefficients and of either of the total employment linkage coefficients are simultaneously greater than one. According to this criterion, key industries for employment generation are the following:

(a) When BL coefficients and STL coefficients are both greater than one, the key industries are: tea, cotton textiles, jute textiles, paper, other chemicals, wood and other manufacturing;

(b) When BL coefficients and HTL coefficients are both higher than one, the key industries are: tea, cotton textiles, jute textiles, paper, other chemicals, wood and other manufacturing. Pharmaceutical manufacturing is the additional industry included as a key industry when only BL coefficients are greater than one.

Other manufacturing industries which have appeared as key industries are defined below:

Table 1. Employment linkages for industrial branches per 1,000,000 taka a/ of output in 1976/1977

Industry	Total employment linkages: By summation (STL)	Total employment linkages: By the hypothetical method (HTL)	Backward employment linkages (BL)	Corresponding linkage coefficients: (STLC)	Corresponding linkage coefficients: (HTLC)	Corresponding linkage coefficients: (BLC)
Tea	82.1	43.37	43.37	1.36	1.42	1.75
Sugar	30.66	17.09	15.63	0. [illegible]	0.56	0.63
Edible oil	18.76	7.71	6.59	0.31	0.25	0.27
Tobacco	8.92	6.22	6.22	0.15	0.20	0.64
Other food	28.43	15.77	15.76	0.47	0.52	0.64
Cotton textiles	108.65	58.96	56.19	1.81	1.97	2.26
Jute textiles	138.18	78.60	69.89	2.296	2.58	2.82
Paper	73.62	33.36	27.68	1.22	1.10	1.12
Leather	14.78	8.92	8.90	0.246	0.29	0.36
Fertilizer	28.75	15.93	15.25	0.48	0.52	0.62
Pharmaceuticals	39.38	26.75	26.75	0.65	0.88	1.08
Other chemicals	117.18	57.86	28.30	1.95	1.90	1.14
Cement	16.94	9.85	9.66	0.28	0.32	0.39
Metal production	54.24	25.89	21.08	0.90	0.85	0.85
Machinery	69.06	30.00	23.14	1.15	0.985	0.93
Transport equipment	29.56	16.69	16.67	0.49	0.55	0.67
Wood	79.6	41.54	38.83	1.32	1.36	1.57
Other manufactures	97.02	90.11	50.99	1.61	2.96	2.06
Petroleum and coal products	138.82	5.71	3.74	2.31	0.19	0.15

a/ The unit of currency in Bangladesh.

(a) Other food includes dairy products, fruits and vegetables, fish and sea goods, rice milling, bakery products, confectioneries, distilleries and soft drinks;

(b) Other chemicals include acids, alkalis and salts, synthetic resins, paints and varnishes, perfumes and cosmetics, soap and washing compounds, matches, disinfectants, insecticides and miscellaneous chemicals;

(c) Other manufacturing industries include aggregation of optical goods, plastic products, pens and pencils, ice, clay products, glass products, pottery, bricks and concrete products, umbrellas, rubber products, ready-made garments, printing and publishing, threads, narrow fabrics and miscellaneous industries.

D. Concluding remarks

Linkage concepts have attained a prominent place in the theoretical literature of development economics. Albert Hirschman originally related linkages to economic development in 1958. But the empirical work on employment linkage has started only recently. High employment linkage industries, if economically efficient and if there is adequate demand for their products, should be assigned priority for investment allocation where a strategy of employment-oriented industrialization is pursued.

The objective of this study has been to identify key industries for productive employment generation within each manufacturing sector. Some of the identified key industries may however be subsequently removed from this group of industries because of efficiency considerations (such as increased use of both production workers and capital) or the loss of economic viability.

There is evidence that labour-intensive industries can be economically viable in the identified small and large manufacturing sectors. A study by the author [6] using information on 97 industries for the period 1976/1977 shows that labour-intensive industries are in general efficient users of capital and the rate of profit per unit of capital or value added is not lower than what would be expected from capital-intensive industries. It is also worth recalling the study by Jan Tinbergen [7] which reveals that labour-intensive activities maximize national product and are major contributors to the reduction of unemployment.

The empirical results presented in this paper refer to the period 1976/1977 and show the relative importance of different industries according to high unemployment linkages.

Key industries for employment generation in the manufacturing sector are reflected in table 2 on the basis of the criteria established in this paper.

Table 2. Key employment industries

Industry	When BL and STL coefficients are both greater than one (BLC)	(STLC)	When BL and HTL coefficients are both greater than one (BLC)	(HTLC)	When only BL coefficients are greater than one (BLC)
Tea	1.75	1.36	1.75	1.42	
Cotton textiles	2.26	1.81	2.26	1.97	
Jute textiles	2.82	2.30	2.82	2.58	
Paper	1.12	1.22	1.12	1.10	
Pharmaceuticals	..	..	..	..	1.08
Other chemicals	1.14	1.95	1.14	1.90	
Wood	1.57	1.32	1.57	1.36	
Other manufactures	2.06	1.61	2.06	2.96	

Annex

SOURCES OF DATA AND DEFINITIONS

This study is based on data drawn from the following sources:

(a) The detailed report on the Census of Manufacturing Industries of Bangladesh for 1976/1977, published in September 1981 by the government Bureau of Statistics;

(b) The 1976/1977 input-output table for the economy of Bangladesh, established by the Planning Commission on the basis of the census of 1976/1977. The input flows include both imported and domestically produced intermediate inputs. The A matrix of technical coefficients of this input-output table has been used, since it is the latest available input-output table for the Bangladesh economy.

The original table constructed for the second five-year plan covering the period 1980-1985 consisted of 47 industries. For purposes of this study, 20 industries were chosen, others being classified as agriculture, construction and services. The other manufacturing industries include ice, clay products, umbrellas, rubber products, ready-made garments, printing and publishing, threads, narrow fabrics, optical goods, plastic products and pens and pencils.

Industry. Throughout this study, industry means manufacturing industry. An industry may be regarded in terms of a group of products similar in their use or production technology. In a census of manufacturing industries similarity of use and production technology are used as criteria for industrial classification.

Employment. The definition of employment given in the census of manufacturing industries of Bangladesh, including employment for all categories of employees and based on the average number of man-years employed, is followed in this study.

Output. Output as used in this study refers to the value of products and by-products at ex-factory prices.

References

1. International Labour Organisation, Employment, Growth and Basic Needs: A One-World Problem (Geneva, 1976).

2. P. Meller and M. Marfán, "Small and large industry: employment generation, linkages, and key sectors", Economic Development and Cultural Change, 1981, pp. 491-542.

3. A. O. Hirschman, "A generalized linkage approach to development, with special reference to staples", Economic Development and Cultural Change, September 1977, pp. 67-98.

4. L. P. Jones, "The measurement of Hirschmanian linkages", Quarterly Journal of Economics, May 1976, pp. 323-333.

5. S. Schuitz, "Approaches to identifying key sectors empirically by means of input-output analysis", Journal of Development Studies, No. 1, 1977, pp. 77-96.

6. Dilip Kumar Roy, "Industrialization and employment: an analysis of Bangladesh manufacturing industries", a doctoral dissertation, University of Antwerp, Belgium, October 1984.

7. J. Tinbergen, "Maximising national product by the choice of industries", Pakistan Development Review, No. 2, Summer 1982, pp. 93-103.

SOME COMMENTS ON ESTIMATING NATIONAL ECONOMIC PARAMETERS FOR JAMAICA

John Weiss*

Introduction

The last 15 years or so has seen the emergence of a large literature on investment appraisal techniques for use in developing economies.** The essence of the approach is an attempt to estimate a set of "shadow" or "accounting" prices, which reflect more accurately than do currently prevailing market prices, the economic costs and benefits of producing outputs and utilizing inputs in new investment projects. Much has been written on the theoretical issues raised by this methodology, and a number of studies have been carried out to estimate such economic parameters in a range of different countries.*** However, despite this interest among academic economists, and the partial use of this approach by international organizations - chiefly the International Bank for Reconstruction and Development and the Inter-American Development Bank (IADB) - it is fair to say that national planning organizations in most developing countries have been slow to adopt these investment appraisal techniques in their own planning and budgeting procedures for new public sector projects. In part this gap between planning practice and the theoretical literature no doubt reflects the difficulty of estimating empirically meaningful values for the key parameters of the methodology. However, one can speculate that in some countries there may well be a suspicion that use of this approach implies acceptance of both a particular analysis of the economic constraints facing developing countries and specifically, a commitment to an external commercial policy of free trade.****

---

*Lecturer, Project Planning Centre, University of Bradford, Bradford, West Yorkshire, United Kingdom of Great Britain and Northern Ireland. The author is indebted to Hugh Latimer for helpful comments on an earlier draft of this paper.

**The seminal works in this literature can be seen as Little and Mirrlees ([10] and [11]) and UNIDO [18].

***Some of the published work on estimating economic parameters include Scott, MacArthur and Newbery [15] on Kenya, Lal [7] on India, UNIDO [19] on Pakistan and Powers [13] on a number of Latin American and Caribbean economies.

Squire and van der Tak [16] demonstrated how wider objectives than simply efficiency in resource utilization could be incorporated quantitatively int appraisals. Linn [8] is one of the few studies which employs this wider approach of "social analysis".

****The link between this investment appraisal methodology and powerful international institutions like the International Bank for Reconstruction and Development would explain this interpretation.

Jamaica was one of the economies studied by the IADB in the mid-1970s when they conducted a series of pilot studies on the application of this approach in the region (IADB [4]). These shadow price estimates for Jamaica appear to have had relatively little impact on actual appraisals, however, and until recently no attempt was made to revise them. In the summer of 1983 the author of this paper was involved in a study to produce current estimates of the main parameters required for the economic appraisal of new investment projects in Jamaica (Weiss [20]). This paper attempts neither to explain the details of the estimation procedures used, nor to summarize the results; information on shadow pricing procedures can be obtained from any of the major texts on the subject, such as Powers [13], and the estimates themselves are to be found in the original study. The intention here is to discuss some points of more general interest arising from the work. The paper is in two sections; the first examines points relating to the practical procedures for deriving shadow or accounting prices for an economy such as that of Jamaica. It is widely recognized that methods of deriving estimates of this nature cannot be standardized, and must take account of the data base, the objective economic situation, and relevant government policies. The second section takes up more theoretical concerns, and discusses the extent to which the theoretical foundations of the methodology allow analysts to conduct appraisals adequately in the Jamaican situation.

A. Derivation of shadow prices

1. Conversion factors for traded goods*

The discussion here follows the procedures set out in the Little and Mirrlees approach to economic appraisal (Little and Mirrlees [10] and [11]) rather than that associated with the UNIDO publications in this area, such as UNIDO [18] and [19]. However, it is now recognized that provided identical assumptions are adopted, analyses using these alternative approaches will give equivalent results. This is demonstrated formally in Weiss [23]. The main difference is one of presentation, with Little and Mirrlees measuring all values at world prices, and applying what is termed a world price numeraire or unit of account. The UNIDO approach, on the other hand, uses a domestic price numeraire. Both approaches are discussed here as part of the general shadow-pricing methodology.

A central premise of the shadow-pricing methodology is that for internationally traded goods world prices reflect the opportunity costs of using these goods as inputs, or the benefits of producing

---

*Conversion factors are simply ratios of shadow prices to domestic market prices (Powers [13]). Weiss [20] employs the so-called "world price numeraire" and therefore values all items in terms of world rather than domestic prices. Hence conversion factors in Weiss [20] give ratios of world to domestic prices.

them as output.* The identification of the relevant domestic and world prices for individual commodities can be both time-consuming and complex, and for this reason a short-cut approach is often adopted in applied studies. This is based on the assumption that for a domestically produced importable commodity the domestic ex-factory price equals the c.i.f. import price for a comparable good plus the rate of import duty. In formal terms therefore the assumption is that, for a locally produced tradeable:

$$D_p = W_p + t \qquad (1)$$

where D_p is the domestic ex-factory price

W_p is the c.i.f. price

t is the import duty

This convenient assumption makes it possible to determine the difference between domestic and international prices simply by an examination of the nominal tariff schedules, and it was in fact employed in the earlier IADB study on Jamaica.** The procedure unfortunately breaks down where protection is in the form of tariffs combined with quantitative restrictions. In this situation the rationing imposed by physical controls on imports will create a scarcity margin which will be in addition to the rate of import duty. There is therefore no way around the problem apart from direct price comparisons that identify the divergence between domestic and world prices, and thus calculate the implicit as opposed to the nominal rate of tariff.

As quantitative import controls have been the major form of protection in Jamaica since the mid-1960s, and as nominal rates of duty have been relatively low, the procedure of simply assuming that differentials between domestic and world prices can be approximated by tariff rates is potentially misleading.*** An illustration of

---

*The degree to which this reflects an implicit free trade bias in the methodology is taken up in section B of this paper.

**One of the earliest statements of this procedure is Schydlowsky [14]. It is used, for example, in Linn [8] and Weiss [21].

***Ayub ([1], p. 12) gives a fairly detailed analysis of the protection system, and comments that:

> "In the presence of quantitative restrictions the Common External Tariff of CARICOM, which is the main fiscal instrument of protection, plays a far less important protectionist role. International price levels are determined for most domestically produced goods by the degree of restrictiveness of the licensing system, and as mentioned earlier, this is exercised without reference to border prices or the equivalent ad-valorem price effect of the tariff."

this can be seen from tables 1 and 2. Table 1 gives data on import duties actually collected in 1982 by two-digit SITC import categories. These average rates of import duty can be compared with actual ratios of domestic ex-factory to c.i.f. prices calculated as part of the study and given in table 2.

Table 1. Average rate of duty collected on imports, 1982

SITC a/ code	Import category	Import value (millions of Jamaican dollars)	Average rate of duty b/ (percentage)
00	Live animals	0.5	0
01	Meat	52.7	1.7
02	Dairy products	65.0	1.3
03	Fish	51.8	1.5
04	Cereals	161.0	4.5
05	Vegetables and fruits	9.4	15.9
06	Sugar and preparations	34.9	0.6
07	Coffee, tea, cocoa	10.0	12.5
08	Animal feed	3.6	0
09	Miscellaneous edible products	9.2	17.4
11	Beverages	9.5	24.5
12	Tobacco	12.6	9.4
21	Hides and skins	0.1	0
22	Oil-seeds	25.8	0
23	Crude rubber	4.9	0
24	Cork and wood	30.7	0.2
25	Pulp and waste paper	0.4	0
26	Textile fibres	2.4	2.0
27	Crude fertilizers and minerals	6.5	0.6
28	Metal ores	0.5	0
29	Crude animal and vegetable materials	5.3	0.4
32	Coal and coke	0.2	0
33	Petroleum and products	700.5	2.7
34	Gas, natural and manufactured	12.7	0
35	Electric current	0.5	0
41	Animal oils and fats	9.6	0
42	Fixed vegetable oils and fats	13.1	1.4
43	Processed animal and vegetable oils and fats	2.0	0.7
51	Organic chemicals	19.4	0.6
52	Inorganic chemicals	92.9	0.3
53	Dyeing, tanning and colouring materials	7.7	3.6
54	Medicinal and pharmaceutical products	36.0	9.5
55	Essential oils and perfumes	26.8	5.3
56	Fertilizers	14.5	0
57	Explosives	0.7	20.6
58	Artificial resins and plastics	45.5	0.4
59	Chemicals n.e.s.	32.6	4.1
61	Leather manufactures	18.0	14.4

continued

Table 1 (continued)

SITC a/ code	Import category	Import value (millions of Jamaican dollars)	Average rate of duty b/ (percentage)
62	Cork and wood manufactures	7.1	12.8
64	Paper and paperboard	60.3	3.6
65	Textile yarn and fabrics	82.9	5.9
66	Non-metallic mineral manufactures	40.7	7.6
67	Iron and steel	54.7	2.5
68	Non-ferrous metals	37.6	0.4
69	Manufactures of metals n.e.s.	60.3	9.1
71	Power-generating machinery	29.9	12.8
72	Specialized machinery	47.3	7.6
73	Metalworking machinery	6.6	10.2
74	General industrial machinery	105.6	11.5
75	Office machines	13.9	32.0
76	Telecommunications	18.2	6.4
77	Electrical appliances	47.6	18.1
78	Road vehicles	160.0	19.3
79	Other transport equipment	11.0	1.2
81	Sanitary plumbing and heating	3.8	30.5
82	Furniture	3.0	17.6
83	Travel goods	1.7	8.3
84	Apparel and clothing	9.3	20.0
85	Footwear	2.1	12.0
87	Professional and scientific instruments	17.1	4.5
88	Photographic apparatus	8.0	19.8
89	Miscellaneous manufactures n.e.s.	53.6	6.6
93	Special transactions	31.0	32.8
94	Firearms	0.3	47.3
	Total c/	2 448.0	7.0

Source: Data supplied by Department of Statistics of the Government of Jamaica.

a/ Standard International Trade Classification.

b/ Includes customs duty plus consumption duty.

c/ Total includes a few items in categories 96-99 - Others - for which no duties are payable.

Table 2. Comparative price ratios in Jamaica, 1982 and 1978

Product	Ratio of domestic ex-factory to c.i.f. prices	
	1982 a/	1978 b/
Food	1.47	1.35
Alcoholic beverages	1.20	1.87
Non-alcoholic beverages	0.77	1.87
Tobacco	..	..
Garments	0.91	1.04
Footwear and tanning	1.40	1.34
Electrical goods	1.52	1.51
Furniture and wooden products	1.16	1.04
Metal products	1.66	1.21
Chemicals	1.20	1.21
Plastics	1.20	1.44
Cosmetics and pharmaceuticals	1.11	1.22
Printing and paper products	1.09	1.50
Automobile parts	1.49	..
Jewellery	0.98	1.20
All manufacturing	1.30	1.34

a/ Calculated from data in Paul Chen-Young Consultants, Structural Adjustments Loan Study, Phases 1 and 2.

b/ Based on data contained in Ayub [1].

2. Conversion factors for non-traded goods

It has been recognized since the development of shadow-pricing procedures for investment appraisal that one of the major areas of difficulty lies in the treatment of non-traded sectors. Goods which can be bought and sold on the world market can normally be valued at international prices, but no such procedure can be adopted for non-tradeables.* The crudest method suggested for solving the valuation problem for goods produced by such sectors is to apply an economy-wide average ratio of world to domestic prices, conventionally termed the standard conversion factor, to reduce their domestic prices to a world-price-equivalent figure. In applied work the standard conversion factor is often estimated using the average rate of tariff-cum-subsidy formula, so that:**

---

*UNIDO [18] stressed that the definition of non-traded sectors could encompass not only goods which are non-tradeable due to their particular characteristics, but also those rendered non-tradeable by deliberate government policies.

**Weiss [21] discusses the role of the standard conversion factor in his shadow-pricing study for Pakistan (see also UNIDO [19] for a detailed discussion of the assumption, upon which it is based).

$$SCF_t = \frac{M + X}{(M + T_m) + (X + S_x - T_x)} \qquad (2)$$

where SCF_t is the standard conversion factor for year t.

M and X are the value of total imports and exports at c.i.f. and f.o.b. prices, respectively, for year t, converted at the official exchange rate.

T_m and T_x are total taxes collected on imports and exports, respectively, in year t, and S_x is the total subsidies paid on exports.

The formula is based on a number of limiting assumptions. Central is the assumption concerning the differential between the domestic and world prices of domestically produced tradeable goods discussed above. The formula also incorporates exportable commodities, and assumes that those which can be sold in the domestic market will sell at a domestic price determined by the export price plus the net subsidy on export sales; any export taxes are treated as a negative subsidy. Therefore, aside from its other limitations, the fact that the formula does not allow for the price effect of the quantitative import controls system means that it is inapplicable in the case of an economy like that of Jamaica, in which such quantitative controls are the main form of protection.*

It must be stressed that the fact that applied studies have resorted to such a crude formula to derive shadow price estimates for non-trade items reflects the gulf between practice and theoretical recommendations. Little and Mirrlees [11] argue the SCF should only be used for minor items for which no more detailed information is available. They are clear that the important non-traded sectors should be examined individually and separate conversion factors calculated for them. When this is done the average conversion factor for the whole economy can be derived from a weighted average of the conversion factors for the main sectors of the economy.**

It is now generally accepted in work of this nature that non-traded sectors can be treated most accurately using a "semi-input-

---

*An important contradiction implied by the use of the simple formula is that the weighted price differential for traded goods, which is all that is being measured by the formula, is employed to revalue non-traded goods in terms of world prices.

**This is the way in which the standard conversion factor is derived both in Scott, MacArthur and Newbery [15] and in Powers [13]. It should be noted that following this procedure the standard conversion factor is no longer strictly equivalent to the reciprocal of the shadow exchange rate, since calculations of the latter are normally only concerned with traded goods.

output" approach.* The objective is normally to revalue the output structure of non-traded sectors to allow for the divergences between domestic and world prices for the different components into which sectoral output can be divided. In a semi input-output system, in principle, it is possible to break down all items in terms of a relatively small number of "primary inputs", where these normally cover foreign exchange, unskilled and skilled labour costs, taxes and capital costs. The conversion factor for any particular non-traded sector is therefore a weighted average of the conversion factors for these primary inputs, with the weights determined by the respective shares of these primary inputs in sectoral output. Without wishing to stray too far into the mechanics of the method, the key step involves identifying the total, that is direct plus indirect, primary inputs going into a particular sector. This can be obtained by constructing a partitioned input-output table; an A matrix gives direct inputs into sectors from other non-traded sectors, and an F matrix gives direct primary inputs into sectors. The essential point is that primary inputs are supplied from outside the system, while non-traded inputs are produced within it, and an expansion of their supply will generate a set of demands for primary inputs. Therefore, whenever the supply of non-traded sector i expands, this generates a set of direct primary inputs requirements, given by the coefficients of the F matrix, and an indirect set resulting from the primary inputs going into the non-traded or produced inputs used in sector i, and determined by the coefficients of the A matrix.**

---

*Kuyvenhoven [6] gives a theoretical explanation of this approach, while Powers [13] shows how it can be applied in detail.

**In matrix terms the solution for a set of conversion factors can be expressed as follows:

$$P = PA + P_f F$$

where P is the final set of conversion factors for the non-traded sectors.

P_f is the set of conversion factors for the primary inputs.

A and F are the matrices of direct coefficients at market prices for non traded inputs and primary inputs respectively.

Solving for P gives

$$P + P_f F\ (1 - A)^{-1}$$

so that the solution is the familiar one of inverting the A matrix.

The data requirements of a semi-input-output approach should not be underestimated, however. The availability of a national input-output table is a useful starting-point, but clearly is not essential.* What is required is fairly disaggregated sectoral data from either sample surveys on individual company accounts. For Jamaica the most that the author could obtain were data collected by the Department of Statistics for the compilation of national accounts. They allow output of the major non-traded sectors to be disaggregated into a number of separate categories - wages, depreciation, operating surplus, taxes and intermediate inputs. The limitations of this crude breakdown for a detailed exercise of a semi-input-output type should be clear. For example, no distinction is made between skilled and unskilled labour, taxes refer only to taxes on final output not on inputs used by the sectors, and most seriously the data are not sufficiently good to allow an accurate disaggregation of the heterogenous category of intermediate inputs. There are ways around some of these problems. For example, certain estimated coefficients taken from similar studies on other economies** could be used. However, in the time available it was felt that a full semi-input-output system based on adequate data could not be developed.

As an alternative Weiss [20] used the simpler approach of expressing the conversion factors of the main non-traded sectors as a set of simultaneous equations.

This simplified approach is at a cruder level of disaggregation than a semi-input-output system, since sectoral output is decomposed into foreign exchange, payments to domestic factors and purchases of non-traded inputs. Values are found for these non-traded inputs through the solution of the system of equations. The number of equations used was small however, covering only four non-traded sectors, the average conversion factor, and the conversion factors for skilled and unskilled labour and investment expenditure.*** The small number of equations plus the difficulty of identifying some intersectoral transactions reflects the limitations of the data available.

---

*IADB [5] gives an updated input-output table for Jamaica, however it is too small for the present purpose, giving only a 12 by 12 matrix.

**For example, this approach was followed to divide wage costs between skilled and unskilled workers. Powers [13] gives data on the proportions of these labour costs in the main non-traded sectors in Barbados.

***The system of equations can be expressed as follows.

$$CF_1 = a_1 + b_{11}\, CF_1 \;\ldots\ldots\; b_{n1}\, CF_n$$

$$CF_n = a_n + b_{1n}\, CF_1 \;\ldots\ldots\; b_{nn}\, CF_n$$

where there are n equations: 1 to k refer to non-traded sectors and 1, m and n to to n labour and investment

The approach used has the advantage of consistency since it allows for the important interdependence between the values of the various parameters; however, too much weight cannot be placed on the accuracy of the results for specific non-traded sectors. A number of different assumptions were used, so that different sets of results were obtained. For the base or most likely case, the economy-wide average conversion factor was found to be around 0.80, with the conversion factors for construction, electricity and transport clustering around 0.75. Distribution is the only major non-traded sector examined, for which the conversion factor of 0.60 differs significantly from those found for the other non-traded sectors. The explanation for its low figure lies in the high labour component - both hired and family labour - in distribution.

On the basis of the data currently available in the Jamaican case it may not be possible to do much more than use a single conversion factor for the major non-traded sectors, apart from distribution. However, even this crude approach should be preferable to the simple standard conversion factor formula equation (2) discussed above. It should be noted, on this point, that non-traded sectors should be expected to have lower conversion factors than the economy average, since exportable sectors with conversion factors approaching 1.0 should raise the average. Nonetheless, the limitations of both the estimation procedures used and the approximation implied by the application of a single conversion factor for a number of non-traded sectors should not be minimized.

3. Treatment of labour

The treatment of labour is central to any estimates of national economic parameters, since not only must direct project labour costs be adjusted, but labour enters as an input into all non-traded sectors, so that its valuation will be one of the factors determining the conversion factors for these sectors. The comments here will be restricted to the approach used for unskilled labour, since the treatment of skilled labour followed a conventional procedure and raised no issues of wider interest.

---

costs and the average conversion factor respectively for the whole economy. CF_i is the conversion factor for sector i, for example.

a_1 to a_n are constants which vary between equations and reflect the direct foreign exchange content of sectoral output, for the non-traded sectors, and the direct foreign exchange element in labour's opportunity cost for the valuation of labour.

b_{11} to b_{nn} are the weights placed on inputs from other sectors and labour in the various equations, so that b_{in} is the share of inputs from sector i in the value of output in sector n at market prices.

For several equations there are many b coefficients of zero, reflecting the crudeness of the data.

The economic cost of employing labour is normally defined in terms of output foregone in the labour-supplying sectors, where this output is valued at shadow and not market prices.* The most general formula for this definition of the shadow wage is therefore:

$$W = x_i \ a_i \ m_i \ \alpha_i \qquad (3)$$

where W is the shadow wage

a_i is the proportion of new workers coming from sector i

so $\sum_i a_i = 1.0$

m_i is the output foregone per worker at domestic market prices in sector i

α_i is the conversion factor for sector i which translates output foregone into world prices

x is the number of new workers leaving their previous activities for every one new job which is created.

The above expression for W allows for the following possibilities:

(a) More than one worker may migrate in response to every new employment possibility;

(b) These migrants can be drawn from a range of sectors;

(c) Their direct opportunity costs for the economy may differ at shadow and market prices.

Output foregone at market prices is normally based on some estimate of the earnings workers would have received in their previous employment, and this was the approach followed in the Jamaica study. However, a common assumption used in shadow wage estimates appears inapplicable in the Jamaican case. It is that agriculture provides the sole source of labour for new projects in other parts of the economy, and that there are a large number of potential agricultural migrants seeking work. This view has been formalized in the Harris-Todaro model of migration patterns in developing economies, and, in terms of the equation for W, implies that the weights a_i refer only to branches of agriculture, and that x exceeds 1.0.

---

*This is the shadow wage for economic analysis. The inclusion of growth and distributional objectives alters the definition of the shadow wage (see Squire and van der Tak ([16], pp. 78-97)). This wider definition of the shadow wage is considered in section B of this paper.

This approach appears questionable for Jamaica however. A steady move to the urban areas has been going on for most of the post-war period, so that in comparison with many other developing economies, Jamaica currently has a relatively low proportion of its total work-force in agriculture. Moreover, with changing attitudes towards farming many entrants to the work-force appear to view agriculture as an inferior activity and prefer to seek employment elsewhere. Furthermore, the major recession in the economy since the mid-1970s and the consequent high rates of recorded urban unemployment appear to have partly checked the migration flow from rural to urban areas. A rough examination of employment and population statistics suggests that the majority of new jobs in the parishes of Kingston and St. Andrew filled since the early 1970s have gone to workers already resident in these parishes, and that net migration in response to these employment opportunities has been relatively low *

In the light of this position it seemed preferable to employ an alternative view of migration patterns. The assumptions used in the study were as follows:

(a) Only one migrant left his previous employment for every new job created on a new project;

(b) Rather than agriculture being the sole source of labour supply for new projects, workers would be drawn from labour-supplying sectors in direct proportion to the current distribution of employment.**

These assumptions combined imply that the shadow wage is a weighted average of estimated output foregone per worker in various branches of the economy, with the weights determined by the current employment pattern. Although the approach is no doubt crude, it can be justified by the fact that what is being estimated is a national or aggregate shadow wage, which might be employed to revalue labour costs in any sector. Individual studies or projects might require a more detailed approach which estimated either a regional or a project-specific shadow wage, and therefore considered the characteristics of particular branches of the labour market.

On the basis of assumptions (a) and (b) and estimates of output foregone in various supplying sectors, the shadow wage for unskilled labour was estimated to be 55 per cent of the current wage. The estimate was not very sensitive to varying assumptions about the proportions in which new workers would be drawn from different sectors; the highest figure derived was 60 per cent of the market

---

*See Weiss [20]. The analysis is fairly crude however, and the conclusion cannot as yet be taken as definitive.

**Formally, this is equivalent to assuming that in response to a small increase in the wage rate the elasticity of demand for labour in all sectors is 1.0.

wage and the lowest 44 per cent.* The results will be familiar for those accustomed to shadow pricing studies, since a shadow wage of around half the market wage is a common finding.** It reflects a situation in which there are substantial productivity and earnings differentials between sectors of an economy, so that there is a possibility of raising real national income by shifting labour from low to high productivity branches. The existence of open unemployment and underemployment should be covered in the shadow wage estimate through the relatively low figures placed on output foregone in labour-supplying sectors.

B. Some theoretical comments

1. Free-trade bias

The degree to which the shadow-pricing methodology discussed here is based upon an implicit free trade development strategy was discussed at length soon after the publication of the seminal works (Little and Mirrlees [10] and [11] and UNIDO [19]).

One major point of debate was the classification of commodities into traded and non-traded goods. Traded goods must be valued directly at international prices, and for commodities in this category it is assumed that whether or not they are used or produced domestically, an economy always has the option of buying or selling them on the world market. Little and Mirrlees [10] argued that if protection removed a number of commodities from this category and rendered them non-tradeable, the analysis could still proceed on the assumption that economically unjustifiable trade controls would be removed in the future. This assumption was quite clearly questionable, and it was pointed out that deliberate trade policy, just as much as the physical characteristics of commodities, could make them non-traded for a particular economy, even if other economies might trade internationally in the items concerned. The consensus since this early debate has been that government trade controls cannot simply be assumed away, and that shadow-pricing analysis must operate within a given institutional and policy environment. The willingness and ability to extend the category of non-traded items is illustrated clearly in the major IADB study (Powers [13]), where relatively large parts of the economy examined are treated as non-traded, and the estimation procedure is extended to cover the more difficult categories of non-traded goods.***

---

*All these estimates are for workers employed in new non-agricultural projects. Agricultural project labour must be treated differently.

**For example, similar results are reported in IADB [4] for Jamaica in the mid-1970s, and in Powers [13] for Barbados.

***These refer to "partially non-traded goods" and "non-traded goods in fixed supply".

Even if the initial attempt to assume away protection, and thereby implicitly introduce free-trade criteria through the classification of commodities, by and large has been rejected, the objection might still be raised that by valuing traded goods outputs at world prices, new projects are expected to be competitive with the least-cost suppliers on the world market. In other words, if project costs are not below benefits, which for traded goods will normally be direct foreign exchange savings and earnings, investment will not be approved, so that local suppliers are expected to have costs which are internationally competitive. In principle, the response to this point was given by Little and Mirrlees [9] when in reply to critics, they argued that the methodology they were recommending was based on an "optimal" rather than a free-trade strategy. This distinction stems from the arguments in the conventional trade theory literature used to justify divergencies from free-trade.* Apart from the familiar terms-of-trade arguments, it is recognized that factors like wage rates in excess of domestic opportunity costs of labour, learning-by-doing, and production externalities can all justify establishing new industries which are not initially competitive with imports at prevailing market prices. An optimal trade strategy therefore implies the protection or promotion of new domestic industries which can be defended on grounds such as these. In terms of policy prescriptions however, neo-classical analysis recommends a set of promotional tax-subsidy measures rather than tariffs and quantitative import controls as a means of establishing new industries (Little, Scitovsky and Scott [12]).

In principle, therefore, shadow-pricing analysis can be used to quantify the importance of the factors which justify the protection of new projects; in other words, for traded goods production the costs that must be compared with the value of output at world prices must be adjusted for factors such as market wages rates in excess of shadow wages, externalities and learning effects.** In practice, some of the more dynamic elements in the case for protection may be extremely difficult to quantify at the project level, and if they are omitted either by design or by default due to these practical difficulties, there is no doubt that the implementation of shadow-pricing analysis may be open to charges of bias. The example of externalities is instructive. There is total consensus that they should be quantified and included in an appraisal, if this is feasible. However, Little and Mirrlees [11] question their quantitative significance for many projects.

The most satisfactory resolution of this dilemma, in the view of the present author, is frankly to acknowledge some of the areas of uncertainty regarding shadow-pricing procedures, and to combine

---

*See, for example, Bhagwati [2].

**In an analysis using a world price numeraire all values will be at world prices. It is now generally recognized that the question of a world or domestic price numeraire, per se, is not a matter of concern on theoretical grounds.

use of the methodology with other planning techniques, whether macroplanning models, input-output analysis, or some form of sectoral targeting, which attempt to cover some of the most dynamic aspects of planning. The premises upon which shadow-pricing analysis is based - that developing economies should attempt to plan their participation in world trade or relative economic costs - remains valid for all but totally autarkic economies, although as far as possible it is dynamic rather than static comparative advantage which should determine investment decisions.

Therefore, despite its advocacy by international institutions which often recommend forcefully that developing economies should adopt a particular set of economic policies, the application of the methodology need not be linked with such strategies.* It is not inconsistent to argue that world prices represent the terms upon which an economy can participate in world trade, and therefore are relevant for planning new investment projects, while at the same time rejecting the economic logic behind a move towards free trade and dismantling of the protection system. In the case of Jamaica this means questioning the wisdom of the structural adjustment programme, which would open manufacturing to foreign competition. Table 2 gives some data on the lack of price competitiveness of much of manufacturing in early 1982. The argument that the major devaluation in 1983 will be adequate to make the sector price competitive with imports appears dangerously misleading in all but the short term, since the feedback effects of devaluations on internal prices are well known. There is substantial evidence from a number of economies that unless it is combined with severely deflationary fiscal and monetary policies, devalution does relatively little for price competitiveness in the medium term (Thirlwall [17]).

2. Exchange rate changes

Exchange rate changes may be forced upon an economy due to weakness in its balance of payments, or may be adopted as an explicit policy to improve trade competitiveness. In either of these circumstances, if a future devaluation is forecast in the short or medium run, it is necessary to attempt to incorporate its impact on shadow price estimates. At one level this can be seen as a practical problem of forecasting, but at another, theoretical problems are raised by the method of allowing for the relative price changes caused by devaluation.

One problem can be set aside initially. The existence of multiple exchange rates, such as the official and parallel market rates, poses no theoretical difficulty. In a system of shadow

---

*Irvin [3], for example, argues that because of its rejection of market prices as measures of social value the methodology represents a major break from neoclassical analysis, and is most directly relevant for decentralized socialist economies. This view may partly explain the apparent paradox that one of the developing economies which has experimented most with the methodology is Ethiopia.

pricing which employs a world price numeraire, all effects must be valued at world prices. Hence it makes no substantive difference what exchange rate is used to translate world prices into local currency. The choice of exchange rate will determine absolute not relative values, and it is relative values which are important for resource allocation decisions. All that matters is that one single exchange rate is selected for all calculations and that it is used consistently.*

However, if the position of foreign exchange reserves is expected to weaken over the medium or short term, so that an exchange rate change appears likely, a major problem arises for shadow-pricing analysis. The distinction is between the current situation, which may, as in Jamaica in 1983, see the existence of two exchange rates, and a future situation with a worsening balance of payments and a major exchange rate change. The economic consequences of the latter should be incorporated in the shadow price estimates, while at the same time one would wish project selection to work in the same direction as other aspects of economic policy. Devaluation can be interpreted as an attempt to alter relative prices in an economy, raising those of traded goods relative to those of non-traded goods.** In this way use of the former as inputs should be discouraged, and their production as outputs encouraged; these twin effects should, other things being equal, help reduce the seriousness of the balance-of-payments position.

If decision-taking on projects is also to achieve the objective of stimulating production of traded goods vis-à-vis non-traded goods, and of encouraging the use of non-traded inputs relative to traded inputs, a means of altering relative values is needed. As Little and Mirrlees ([11], p. 354) put it "... if a devaluation will take place, and will have some differential effect on the social profitability of different projects, then this should be reflected in the choice of projects now".

The more straightforward means of achieving a revised ranking of projects in the light of forecast changes in foreign exchange availability is in the use of an adjusted shadow exchange rate.

---

*Scott, MacArthur and Newbery [15] make the same point in relation to Kenya. Admittedly, if some effects are valued in domestic and some in world prices, then the choice of exchange rate becomes of critical importance; hence the attention given to shadow exchange rates in shadow-pricing studies using a domestic price numeraire.

**Since the impact of higher import costs on the international price level can upset these relative price changes, it can easily be shown that if wage costs are allowed to rise at the same rate as prices, and if profit margins are a fixed proportion of costs, then internal prices will rise at the same rate as import prices (Thirlwall [17]).

This is not possible in the world price numeraire system since all items are valued directly at world prices and no shadow exchange rate is required to move between domestic and world prices.* In the world price numeraire system the increased scarcity value of foreign exchange is allowed for, in principle, through a downward revision to the shadow wage, and thus to the conversion factor for labour. Since labour enters as a cost in the production of all non-traded commodities, their shadow prices are lowered relative to traded goods, or in other words, non-traded items are devalued. Therefore an anticipated devaluation implies the need for a downward adjustment to the shadow wage.

An explanation of the logic of this argument and the theoretical problem it causes requires a brief digression into the question of the full valuation of labour in a social as opposed to an economic analysis. The definition of the shadow wage for unskilled labour given in the first part of this paper focused only on the foregone output of labour, or direct opportunity cost. However, if growth and equity objectives are introduced into the analysis, the definition of the shadow wage for unskilled labour is widened considerably; it now covers both the social costs - loss of reinvestible surplus - and social benefits - distribution to low income groups - of the extra consumption arising from the employment of unskilled workers. Following Squire and van der Tak [16] this new definition can be expressed as:

$$W^{1} = m\alpha + (c - m)\beta - \frac{d_i}{v}(c - m) \qquad (4)$$

where W^1 is the new social shadow wage.

m is the output foregone in the worker's previous activity at domestic market prices.

α is the conversion factor required to translate m to world prices.

$(c - m)$ is the net increase in the worker's consumption at domestic market prices resulting from his new employment.

β is the conversion factor required to convert this consumption into world prices; it is normally termed the consumption conversion factor.

d_i is the weight placed on an extra unit of consumption going to group i - in which the worker is located - in relation to consumption going to average consumers.

---

*It should be noted, however, that if internal prices rise by the same rate as the devaluation, the real exchange rate will not have changed, and therefore use of a lower adjusted exchange rate will not be legitimate.

v is the weight placed on a unit of uncommitted income in the hands of the Government valued in foreign exchange and potentially available for investment, relative to a unit of consumption going to average consumers.

The complications introduced in equation (3) regarding the sectors from which workers are drawn and the number of workers involved are assumed away, so that:

$$m^{t} = x \sum_{i} a_i m_i \, {}^{t}_{i}$$

The first two terms in the expression for W^1 are the cost of the new worker's employment, and the last term is the social value of the distributional benefit associated with his employment. It is argued that a devaluation will reduce the shadow wage at least in the short run, since as the net increase in consumption (c - m) is a fixed sum at domestic prices, its foreign exchange cost is reduced by the full amount of the devaluation; in other words, any given amount of domestic expenditure is worth less in foreign exchange following a devaluation, and the consumption conversion factor which expresses domestic consumption expenditure at world prices will fall.

The economic opportunity cost of employing a new worker m^{t} would remain unchanged if output foregone were solely in the form of traded goods, since physical quantities lost and world prices would be unaffected. However, some proportion of foregone output of unskilled labour will be in the form of non-traded goods, and these will fall in value with devaluation. The simplest way to see this is by interpreting a fall in non-traded output, as a result of a worker's move to a new job, as a decrease at a demand margin; in other words, since the option of importing to cover the output fall is not open, less non-traded output will be available for domestic consumers. The output foregone will be valued at consumers' willingness to pay, and this measure of domestic prices must be converted into world prices. A consumption conversion factor will be required for the purpose, which may or may not be the same as that used to convert (c - m) to world prices. However, all conversion factors for consumption expenditure must fall to allow for the real reduction in the purchasing power of domestic expenditure in relation to foreign resources.

A theoretical problem arises, however, in that the third term in the expression for W, - di/v (c - m), will also fall as a result of devaluation, since the same consumption increase at domestic prices is involved.* This term reflects the consumption benefit

---

*The role of in di/v (c - m) may not be clear initially, because of the way in which v is defined. However appears in the denominator of the expression for v, so that a fall in leads to a rise in v and a fall in di/v (c - m) (see Squire and van der Tak ([16], pp. 68-71) for a discussion of calculating v). An alternative but equivalent expression for di/v (c - m) would be di/v (c - m) ; this is provided no longer appears in the denominator of v.

resulting from a worker's employment, and if it is initially greater than the consumption cost, so that (c - m) < di/v (c - m) or di/v, there is the theoretical possibility that a devaluation may actually lead to a rise in the shadow wage despite a fall in output foregone and the consumption cost of employment at world prices. The logic of this is that if a high social weight is placed on the consumption of low income groups, a devaluation which lowers real wages will also reduce the consumption benefit of employment; in certain cases this may be sufficient to offset the fall in the first two terms of the shadow wage.

A devaluation which results in a rise in the shadow wage is counter-intuitive, and if such a result were to occur it is clear that shadow-pricing analysis could not be employed in conjunction with stabilization measures aimed at shifting investment in a direction that conserved foreign exchange and utilized more non-traded goods and labour. However, it appears that a devaluation will only unambiguously lower the shadow wage in a social analysis if the weighting system is such that di/v < , or in other words that di/v < 1; additional consumption must be less valuable than income in the hands of Government, which is available for investment.*

Setting aside the theoretical possibility of a counter-intuitive result in the estimation of the shadow wage, there are a number of serious empirical problems in adequately incorporating the consequences of an anticipated devaluation in shadow prices estimates. It is clear that if a devaluation creates a substantial shift in relative prices there are likely to be substitution effects in both production and consumption. For example, input coefficients for non-traded sectors and consumption weights for consumption expenditure conversion factors may change. In theory, the whole set of shadow price estimates for an economy can be affected as a result of such changes.

Squire and van der Tak ([16], pp. 94-95), in acknowledging this problem and discussing the effects of a devaluation, argue that "the information required to trace through these effects (of a devaluation) is formidable, and in practice it may be necessary to ignore the substitution possibilities in both production and consumption, and to concentrate solely on the immediate (relative) reduction in the cost of consumption when making new estimates of shadow wage rates and of marginal social costs for non-tradeables".

However, even focussing on the immediate consumption effect of a devaluation requires a forecast of the extent to which real wages will be reduced. The discussion above on the mechanism whereby the shadow wage is likely to fall after a devaluation assumed unchanged money wages, so that a fall in the consumption conversion factor

---

*If v is redefined, so that di/v (c - m) becomes the benefit of additional consumption, the condition for a fall in the shadow wage becomes di/v < , or di/v < 1.

was not compensated for by a rise in money wages, which increased (c - m) in domestic prices. A projection of the shadow wage requires judgement on how real and nominal wages will be affected by devaluation. The difficulties involved with this type of forecasting may mean that in practice it is difficult to project adequately a shadow wage estimate, and this casts doubt on whether project analysis has an effective role to play in conjunction with more conventional short-term measures of balance-of-payments management. Perhaps the main point is that it is difficult to incorporate future scarcities of foreign exchange in any shadow-pricing system, but where devaluations are covered through adjustments to the shadow wage, the mechanism is more indirect and prone to uncertainty.*

3. Discount rate

One of the most difficult parameters to estimate accurately in shadow price studies is, perhaps surprisingly, the discount rate. Theoretically, if the government investment budget is fixed, the discount rate for new government projects will be defined as the rate of return on the marginal public sector project. This raises both theoretical and empirical difficulties however. Empirically, the marginal rate of return can only be estimated in the "shelf-of-projects" situation, where all projects which potentially compete for investment funds have not only been identified but also appraised at shadow prices. In the present state of investment planning procedures this situation is quite clearly unrealistic. Theoretical difficulties also arise due to the fact that it may not be appropriate to assume that the budget of a Government is rigidly fixed, since there is often likely to be the possibility of drawing upon savings from either the private or the external sectors.

One practical procedure often applied to produce what is taken as an upper limit to the discount rate is a crude analysis based on national accounts data and relating estimated capital stock in the economy to national income minus wage costs and depreciation. Algebraically,

$$q = \frac{Y - (W + D)}{K} \qquad (5)$$

where q is the estimated return on capital.
Y is total national income.
W and D are wages and depreciation respectively.
K is total capital stock.

---

*Accurate use of a shadow exchange rate in a domestic price numeraire system is also open to difficulty, since a projected effective, not nominal, exchange rate change is required. Detailed information on cost structures of non-traded sectors and consumption expenditure patterns may also be needed. It is fair to say, however, that in practice rough adjustments to foreign exchange values to allow for an anticipated devaluation will be simpler to apply in a domestic price system.

All items refer to a particular year, and are given at shadow prices.

Since the marginal return must be at shadow prices, using a world price numeraire, Y, W, D and K must all be converted to world prices. The approach is not only based on crude macrodata, but rests upon dubious theoretical premises. It invariably produces high estimates for q, since labour costs are revalued by a shadow wage often significantly below the market wage, and the resulting surplus is attributed solely to the factor capital.*

Returns attributed to technical progress are ignored, as are the implications of theories of distribution which are an alternative to that of marginal productivity theory.** However, if one is willing to reject certain assumptions of the marginal productivity theory at a microlevel, for example that wages always equal marginal value products, there seems to be no logical reason to accept its macroconclusions that total national income is allocated between two factors, labour and capital, on the basis of their physical quantities and marginal products.

An alternative means of deriving an estimate of the discount rate is relevant for economies that have access to international borrowing. In this case the discount rate is defined as the real cost of borrowing from the marginal or least attractive source, which normally will be the private international capital market. An increasing number of developing countries, including Jamaica, now have access to such funds, and it could be argued that in the same way that world prices for commodities represent the terms on which an economy can participate in world trade and are therefore relevant for planning decisions, so world interest rates are equivalent to international prices for funds, which should also be considered in planning.*** In other words, government budgets should not be

---

*Application of this approach to 1980-1982 data for Jamaica, for example, gives an average q of 17 per cent.

**Marginal productivity distribution theory implies the following equality:

$$Y = Kq + Lw$$

where q is the marginal product of capital.
w is the marginal product of labour.
K and L are the quantities of the two factors.
Y is the national income.

If labour is valued at its marginal product the residual surplus must be the return to capital. The question of the difficulty of identifying a value for capital has been a major source of theoretical debate for many years.

***The author is indebted to Richard Kitchen for the expression of the argument in this way.

assumed to be fixed because of the possibility of international borrowing, which will be economically justified if at world prices the returns on new projects exceed the real interest charge involved.

This definition usually produces estimates rather lower than the normal range considered for the discount rate. The estimates will depend upon the borrower status of an economy, which determines its risk premium above the London Inter-Bank Offer Rate (LIBOR), and critically upon the price index used to deflate the nominal interest charge to real terms. For Jamaica, however, this approach still produced a relatively high estimate for the discount rate of 8-10 per cent, which reflects its relatively weak credit status and the poor price prospects for its traditional exports. Such estimates must obviously be revised in the light of changing world interest rates and price trends.

The essential point to stress regarding the discount rate, therefore, is that given the difficulties and limitations associated with other methods of estimating this parameter, adjusted real international interest rates may be the most appropriate measure for an increasing number of developing economies. Use of an international interest rate does not remove estimation problems, but one can argue that it would be an improvement over much existing practice, which is often either ad hoc or based on conventional views of what is an acceptable discount rate.*

C. Conclusions

This paper has pointed to some features of the estimation procedure for shadow prices used by the author in a recent study of Jamaica It has tried to indicate areas of both practical and theoretical difficulty with the methodology, but despite these, it wishes to suggest that shadow-pricing techniques should be seen as a useful complement to other planning procedures in use at present. Perhaps the most important general point is that shadow-pricing techniques do not necessarily have to imply a free trade bias in terms of allocation decisions. It has been argued that if a bias in this direction arises, it is likely to be through the manner in which analysis is carried out, rather than from its underlying theoretical basis. Careful application of economic analysis to new investment proposals in combination with forms of sectoral and macroplanning is one way of avoiding such a situation.

References

1. M. A. Ayub, Made in Jamaica: the Development of the Manufacturing Sector (Baltimore, Johns Hopkins University Press, 1981).

---

*One can speculate that use of the conventionally accepted range of discount rates of 10-12 per cent owes much to the fact that in many countries for long periods nominal commercial interest rates were around this level.

2. J. Bhagwati, The Theory and Practice of Commercial Policy: Departures from Unified Exchange Rates, Special Papers in International Economics, No. 8 (Princeton, New Jersey, Princeton University Press, 1968).

3. G. Irvin, Modern Cost-Benefit Methods (London, MacMillan, 1978).

4. Inter-American Development Bank, Pilot Study on National Economic Parameters: their estimation and Use in Chile, Costa Rica and Jamaica, Papers on Project Analysis, No. 6 (Washington, D.C., 1977).

5. Inter-American Development Bank, Updating Input-Output Tables by a Modification of the RAS Method with Case Application to Jamaica, Papers on Project Analysis, No. 17 (Washington, D.C., 1979).

6. A. Kuyvenhoven, "New industrial planning techniques: macro-sectoral and project linkages", Industry and Development No. 5, 1980.

7. D. Lal, Prices for Planning (London, Heinemann, 1980).

8. J. Linn, Economic and Social Analysis of Projects: a Case Study of the Ivory Coast, World Bank Staff Working Paper No. 253 (Washington, D.C., World Bank, 1977).

9. I. Little and J. Mirrlees, "A reply to some criticisms of the OECD manual", Oxford Bulletin of Economics and Statistics, vol. 34, No.1 (1982).

10. I. Little and J. Mirrlees, Manual for Industrial Project Analysis in Developing Countries, vol. II (Paris, Organisation for Economic Co-operation and Development, 1968).

11. I. Little and J. Mirrlees, Project Appraisal and Planning for Developing Countries (London, Heinemann, 1974).

12. I. Little, T. Scitovsky and M. Scott, Industry and Trade in Developing Countries (Oxford, Oxford University Press, 1970).

13. T. Powers, ed., Estimating Accounting Prices for Project Appraisal (Washington, D.C., Inter-American Development Bank, 1981).

14. D. Schydlowsky, "On the choice of a shadow price for foreign service", Development Advisory Service Economic Development Report, No. 108 (Cambridge, Massachusetts, Harvard University Press, 1968).

15. M. Scott, J. MacArthur and D. Newbery, Project Appraisal in Practice (London, Heinemann, 1976).

16. L. Squire and H. van der Tak, Economic Analysis of Projects (Baltimore, Johns Hopkins University Press, 1975).

17. A. Thirlwall, Balance of Payments Theory (London, MacMillan, 1980).

18. Guidelines for Project Evaluation (United Nations publication, Sales No. E.72.II.B.11).

19. Practical Appraisal of Industrial Projects (United Nations publication, Sales No. E.79.II.B.5).

20. J. Weiss, "National economic parameters for Jamaica", Project Planning Centre Occasional Paper No. 7 (University of Bradford, 1985).

21. J. Weiss, "Problems in the use of world prices in social cost-benefit analysis", Institute of Development Studies Bulletin, August 1978.

22. J. Weiss, "Project selection and equity objective: the use of social analysis", Pakistan Development Review, Summer 1979.

23. J. Weiss, "Sarania pulp and paper mill", Project Planning Centre, Occasional Paper No. 2 (University of Bradford, 1976).

DEVELOPING LOCAL INDUSTRY THROUGH CENTRES FOR INDUSTRIAL STUDIES IN TERTIARY INSTITUTIONS IN DEVELOPING COUNTRIES

Peter B. U. Achi*

A. Background to the development of centres for industrial studies in developing countries

Technological development in industrial economies has made enormous strides since the eighteenth-century European Industrial Revolution. A modern industrial economy may be described as an economy of which the initial "industrial culture was sufficiently well developed to take advantage of the inventions of the eighteenth- and nineteenth-century Industrial Revolution and to establish the competitive industries that are currently in process of regeneration [1]. In developing countries the emergence of an industrial culture is synonymous with the growth of "indigenous" technology that would form the basis of local industry. Being part of one international market and maintaining active relations with other economies, every developing country must however take into account the existing levels of technology and organization in other countries [2].

Having realized the importance of technology as the foundation of modern industry, some developing countries (such as Ghana, Jordan, Kenya, and Nigeria) are establishing industrial and technology development centres. These centres are assisting small-scale and cottage industries in modernizing their operations and in training industrial personnel in the effort to develop their entrepreneurial capacities. In Jordan, Yarmouk University [3] has a School of Engineering which among other activities has the responsibility of developing local industry through programmes of continuing education and campus-industry linkages.

Some factories are established [3] around the campus of Yarmouk University to reduce the lead time between research and development and the application of results to industry. In Ghana, the University of Science and Technology at Kumasi [4] has a technology consultancy centre with a comprehensive programme of improving technology in local industry. The centre continuously improves the tools in the possession of local craftsmen and mechanics with the aim of increasing their productivity and thus expanding their businesses.

In Nigeria, Industrial Development Centres (IDC) have been established in the eastern, northern and western regions at Owerri, Zaria and Oshogbo, respectively. The centres are charged with the responsibility of providing free consultancy and extension services as well as training in managerial skills for small-scale industrial

---

*Centre for Industrial Studies, Federal University of Technology, P.M.B. 1526, Owerri, Nigeria.

entrepreneurs (who are often unable to employ full-time engineers), managers and technical staff. For the purpose of these services, small-scale industries are defined as any manufacturing, processing or service industry with a capital investment not exceeding $750,000 in machinery, equipment and working capital. In the services rendered by the IDCs the emphasis is on the development of small-scale industries that use machinery and power to make relatively sophisticated consumer goods and also simple producer goods. The free technical services provided by the IDCs include assistance in the selection of proper manufacturing processes and equipment, installation and initial operation of machinery, on-the-job training of small-scale industry artisans in equipment operations, maintenance and repair of machinery and tooling, resolving operation problems and improving small-scale industry products design. The management services rendered by the IDCs include feasibility studies, the choice of management structures, the planning and control of production to enable small-scale industries to reduce costs and improve productivity, counselling in product pricing and other marketing strategies, initiation of small-scale investments for entrepreneurs and acting as an intermediary between Government and small-scale industry.

In Nigeria there are approximately 2,000 small-scale industrial enterprises employing a total of less than 40,000 workers. To help deal with the increasing rate of unemployment, especially among professional graduates of tertiary institutions, the federal and state Governments had opened five universities of technology by 1985, which are expected to produce graduates who are well-equipped to become job-creators instead of job-seekers.

The establishment of universities and schools of technology in developing countries can be seen within the context of the desire to develop indigenous technology influenced by the modern technologies existing in industrial economies. The academic and organizational departures from the type of education offered in traditional universities and schools include the following: practical-oriented academic training; and industrial-oriented research and development.

The establishment of centres for industrial studies within a university or school environment may be seen as serving the purpose for the practical fulfilment of the second of the above-mentioned requirements (namely, industrial-oriented research and development) and the partial fulfilment of the first requirement.

B. Constraints on the practical realization of objectives

In developing countries the achievement of the objectives of IDCs depend considerably on the funds available, on the existing practical expertise and infrastructural facilities and on well-conceived equipment policies for the centres. While it is not necessary to specify the equipment or production processes that the centres should possess, it is important to indicate the constraints on planning, taking into account the availability from year to year of the necessary inputs

1. Funds

From the inception of an industrial centre the finances available to a large extent determine the availability of the other inputs. In most developing countries finance for industrial development is one of the main problems facing the Government. In Nigeria, for example, the three regional IDCs depend entirely on Government subsidies for their working capital since their services are rendered free to small industries. The Centres for Industrial Studies (CIS) of the Universities at Owerri and Enugu and in a few polytechnic colleges depend at present almost entirely on finances from their parent institutions, which in turn are wholly financed by the Government. In recent times the economies of most developing countries have been in such poor condition that funds for urgently needed services such as water, roads and hospitals consume the bulk of their available foreign exchange, leaving very little for industrial development. Nevertheless, the existence of more indigenous industries would help to reduce the amount of scarce foreign exchange spent on the provision of the most essential goods and services (some external assistance in financing may often become necessary). These circumstances should be borne in mind in the preparation of an organizational plan for a centre for industrial studies.

2. Practical expertise

Local professionals with the practical expertise necessary for the development of indigenous modern technology are in short supply in developing countries. The few developing country professionals at home and abroad usually require definite financial and other incentives to attract them to the industrial centres. With such professionals the centres could widen their scope of operation from industrial education to commercial ventures. Qualified professional engineers are crucial for this purpose.

3. Infrastructural facilities

The availability of adequate space, buildings, water, electricity, ancillary technologies etc. influence the scope of operational planning.

4. Equipment

The CIS operations would include consultancies, subcontracting, product development and student training. The basic principle of maximum utilization of equipment in engineering production demands that wherever the variety of products is large and the quantity small (as in general CIS operations), general-purpose equipment would be more economic. The acquisition of special-purpose equipment would then be minimized especially in the first three years of operation of the CIS.

C. Practical role of centres for industrial studies in developing countries

The principal functional role of a centre for industrial studies operating from a university or school of technology is generalized in the model presented in the figure. This model can be further compressed into the following schematic representation:

CIS strategy	Student training Technical products development Pilot plant development Social functions (including consultancy services and seminars)

1. Student training

In developing countries this is one of the crucial aspects of the role of technical educational institutions. For the CIS this role is the production of graduates possessing at least one practical skill required by the local industry in addition to a general education in the graduates chosen discipline of science or technology. The responsibilities of institutes of technical education for industry in developing countries include the following: general academic education (in departments); interdisciplinary practical and laboratory training (in departments and CIS); and skill-oriented industrial training (in CIS and industry). At the Federal University of Technology at Owerri in Nigeria a three-tiered system of education along the above-mentioned lines is expected to produce finished graduates, with a centre for industrial studies being used to accentuate the practical aspects of the training.

2. General academic education

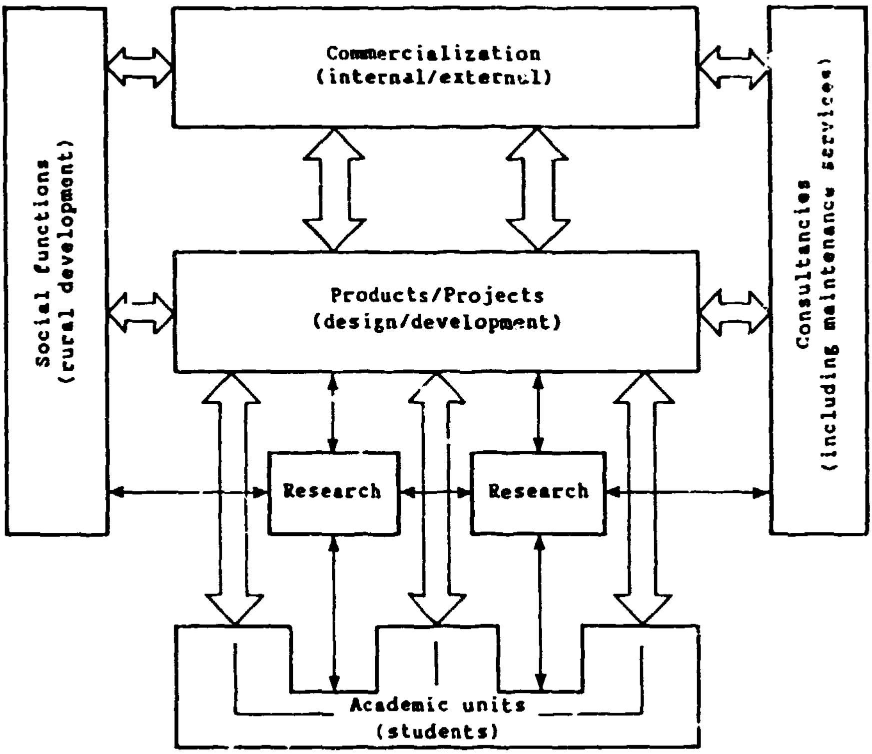
General academic education is offered through the specific programmes of the academic departments as embodied in well-balanced curricula based on the needs of the country and fully supported by practical teaching methods and adequate laboratories. As a result of serious financial constraints, tertiary technical institutions in developing countries often lack basic laboratory facilities. Given the serious shortage of such facilities, the academic and professional staff recruited by the institutions should possess the necessary training to enable them, in the absence of a functioning laboratory, to improvise practical examples of the subject matter of their particular disciplines. The present staffing situation in many of the institutions, however, reveals a preference for academic excellence over practical skills, which tends to delay the acquisition of indigenous technology for rapid industrial development.

By the fifth year of its existence a CIS should be able to rely on the expertise of academic departments to help improvise some of the required laboratories. The readiness to improvise is reflected in the commitment of the institutions to practical work.

3. Interdisciplinary practical training

Interdisciplinary practical training evolves partially from general academic education supported by laboratories to more general practical training which goes through the production process from basic raw material inputs to the finished products. For the engineering, science and management technology students at the Federal

Generalized functional model of an industrial centre in a tertiary institution



University of Technology at Owerri, Nigeria, the general practical aspects of their training involve the machine and fitting shops, the electrical shops, the technical drawing department and the chemical laboratory, all in the CIS environment. The CIS controls the equipment used for this level of training by providing the technical co-ordination of the facilities and the principal teaching staff, while the academic departments provide the complementary staff.

The departments technically advised and supported by the CIS develop products- or process-oriented practical training based on the academic courses offered by the departments. Practical training at this level is different from the above-mentioned academic laboratories since it is generally industry-oriented. Technological institutions (even without an industrial centre) in developing countries should not leave this aspect of training out of their curricula (as is currently the case), otherwise the training would produce only academic experts of little use to industries in those countries. It would also be unwise at this stage to "regiment" the subject-matter of practical industrial training courses because the desired flexibility consistent with rapid economic and technological change could be lost.

4. External industrial assignments

The type of training thus far described is equivalent to in-house industrial work experience schemes for students, but since the training is carried out within the academic environment of the CIS its total industrial content may be inadequate. The important objective of "industrial assignments" is to ensure that a sizeable portion of industrial training is carried out in external industries engaged in competitive production and services. Midway through a course some external industrial assignment of students (even for brief periods) is necessary for the following reasons:

(a) To enable the student to acquire a general knowledge of the working of industry outside the academic environment of the CIS;

(b) To enable the student to gain more specific experience in financial management and in cutting losses in the running of a competitive industry;

(c) To take advantage of the fact that the scope of operation of the CIS in a developing country is most likely to be limited initially to a few industrial disciplines.

The author's experience in the co-ordination of industrial work experience schemes for students in Nigeria is that, among other problems, only few industries have adequate facilities for industrial training. Therefore the last half of the course would be mainly spent in the CIS to impart specific industrial skills.

5. Specific skill-oriented industrial training

Skill training is a logical follow-up of earlier inter-disciplinary training. It is here that an attempt is made to equip the CIS students with certain practical industrial skills. A conscious effort is made to relate both the needs of the local community and the students' experiences during external industrial assignments to specific industrial practice covered in CIS curricula. The appropriate staff is selected and temporarily attached to the CIS to enable the students to benefit from the practical expertise of the staff members in particular areas of study. Such a practical approach helps to ensure that "industrially competent" graduates emerge from the CIS and can opt for self-employment, with some of the products developed in the CIS provided under special loan arrangements to help them start their businesses.

Products and skills are developed during the project- and product-oriented practical skill training, interspersed with the discussion of relevant management practices. New and improved products and pilot plants would be continuously developed during this final phase of training. The institution and the Government may have working agreements with commercial banks whereby the former would guarantee loans granted to skilled graduates to start their own businesses. In Nigeria, the Nigerian Industrial Development Bank is best placed to participate in this plan. Similar banks e-ist in many developing countries. The principal objectives of the training are as follows:

(a) To promote entrepreneurial skills in developing countries;

(b) To reduce unemployment;

(c) To develop indigenous technology as the basis of local small-scale industry, thus enhancing the standard of living of the local communities (at the time of writing, these plans were still only proposals in Nigeria).

D. Services provided by the CIS to local industries

Besides training future industrial experts and developing local entrepreneurs as described above, the CIS has other functions to fulfil for local industry. Among these functions is the training of personnel already working in modern industries. The CIS admits industrial personnel on a full-time or part-time basis for short courses designed to improve the technical and managerial skills required for their jobs in industry. The training is usually sponsored by the industries concerned and may be in such specialized areas (depending on the equipment available) as the following: programming and operating numerically controlled machines; advanced machinery operations, modern auto-diagnostic equipment and repair techniques; industrial waste disposal technologies; modern materials and forming operations; and other areas of importance to local industry. The principal responsibility of the CIS, however, will remain the development of small industries, especially in rural areas.

1. Technical consultancies to local industry

(a) Existing industries

Depending on its available technical expertise, the CIS should seek to establish consultancy arrangements with local industry in order to generate more funds and increased financial support from the parent institution. In many developing countries the operational areas posing considerable problems to local industry include the repair and maintenance of imported machinery. These machines are often classified as "appropriate" technologies, although they may have been long outdated in the exporting country [2]. Many struggling industries in developing countries (such as the cement-making industries in Nigeria) are almost fully equipped with machines that are no longer manufactured abroad, and for which no more stocks of spare parts are available from the manufacturer. Nigerian cement factories have been known to lie completely idle for up to two years as a result. Even in other industries where spare parts may be available abroad, there would be no foreign exchange for their purchase. In such cases the CIS should be equipped to manufacture spare parts to enable these industries to resume operations quickly enough to prevent an increase in unemployment rates.

Other areas where expert consultancies are often necessary in developing countries include readjustment of production systems (for instance through the simplification of manufacturing methods), research into local raw materials for specific industries, adaptation of foreign products to local conditions and value analysis to reduce the cost of local products.

(b) New industries

The new products and pilot plants developed through practical research in the CIS would be sold to existing industries or used to help CIS graduates start new industries, as noted earlier. When the products and pilot plants form the basis for new factories, the latter would qualify as small-scale industries for numerous government incentives.

The role of the CIS in the formation of new industries is crucial. For developing countries this role would help to reverse the present trend of importing factories from outside the country by way of turnkey projects. Turnkey factories create problems of future maintenance, as previously mentioned, and adverse working conditions, being culturally alien to the local worker. Unnecessary turnkey projects can be avoided by allowing the CIS to act as the middleman in national and international industrial agreements and to promote the development of production processes based on the adaptation of existing foreign technologies to local conditions.

2. External inputs

It would not be necessary for developing countries to attempt to "reinvent the wheel" by independently developing technologies existing in developed countries if the latter were willing to share their knowledge. In cases where developed countries are willing, the CIS in developing countries could be used to acquire the technologies required to meet the needs of local industry. Staff of the CIS and the companies of co-operating developed countries can exchange frequent visits and short training courses can be organized for the CIS staff.

The technologies would subsequently be disseminated through the CIS to local industries. This partial approach to industrialization should be recognized by developing countries as being as essential to the growth of local industry as the development of indigenous technology.

CIS research and teaching efforts should also include the application to local industry of research findings disseminated through local and foreign journals and conferences.

E. Other socio-economic functions of a centre for industrial studies

In the final analysis, all the activities of the centre for industrial studies in a tertiary institution are expected to serve the society around it in one way or another. Each activity is therefore designed to help solve problems facing society in the following ways:

(a) Through research. The CIS should be actively involved in investigating technical and socio-economic problems of both immediate and long-term interest to the community, such as rural waste management and soil erosion. The research effort and follow-up activities should proceed along the following lines:

(i) Continuous monitoring of socio-economic and technical problems at both the local and national levels;

(ii) Immediate initiation of studies (provided funds are available) and gathering of the data required to find solutions to the problems dealt with;

(iii) Prompt dissemination of the research findings by way of local advertisements through local government councils, extension workers and even announcements by village criers;

(iv) Mobilization of research results and products (internal and external) for quick application to rural industry;

(b) Through seminars and workshops. Another channel for publicizing local research findings and acquiring new industrial knowledge is by way of workshops and seminars organized by the CIS. The seminars could be in any socio-economic or technical area that affects industrial development. Local television (if available) and radio talks could also be employed to publicize the work of the centre to the local community. Technical publications from the CIS should be practically oriented and written in simple and clear language so that they can be easily understood by ordinary people;

(c) Through the mobilization of local tradesmen. The CIS should appoint a technical liaison officer between it and local craftsmen and repair mechanics in the community. The location of mechanics and craftsmen in "mechanics villages", as in Nigeria at present, has facilitated liaison with the CIS (at Owerri, for example). The purposes of the link are as follows:

(i) To co-ordinate the various technical skills possessed by tradesmen for developing products and services for the community;

(ii) To improve the standard of craftsmanship and job satisfaction of the tradesmen;

(iii) To improve management techniques and hence increase the profitability of enterprises.

F. Conclusions

While co-ordinating the professional activities of the academic and technical branches within a tertiary institution, a centre for industrial studies should keep in constant focus the industrial needs of the outside community.

Since the majority of the population of developing countries resides in rural areas, these countries cannot develop industrially while leaving the rural population behind. Creating a general awareness of technological problems and finding practical solutions to rural needs are therefore important responsibilities of a CIS operating from a tertiary institution in a developing country. One of the most effective ways of meeting those responsibilities is by using the CIS to equip local graduates with entrepreneurial skills using products and techniques related to local needs and developed though studies in the centre. The enterprises thus established would benefit from the government incentives usually provided for small-scale industries in developing countries.

References

1. P.B.U. Achi, "How best can the universities of technology help industrialize Nigeria?", paper prepared for the International Conference on Science and Technology Education and Future Human Needs, Bangalore, India, August 1985.

2. P.B.U. Achi, "'Indigenous' and 'appropriate' technologies in developing countries", paper prepared for the International Conference on Science and Technology Education and Future Human Needs, Bangalore, India, August 1985.

3. R. Sharif, "Transfer of appropriate technology", paper prepared for the International Conference on Science and Technology Education and Future Human Needs, Bangalore, India, August 1985.

4. J. W. Powell, "Technology transfer to small industries in Ghana", paper prepared for the International Conference on Science and Technology Education and Future Human Needs, Bangalore, India, August 1985.

SOMMAIRE

L'industrie des circuits intégrés en Inde et en République de Corée et son environnement technico-économique international

Charles Edquist et Staffan Jacobsen

L'Inde et la République de Corée ont adopté des stratégies fort différentes pour développer les capacités nationales de production de circuits intégrés, activité à haute technologie généralement dominée par les fabricants des pays développés. Après avoir brièvement défini le terme "circuits intégrés", l'article donne une vue d'ensemble de l'industrie mondiale pour décrire aussi l'environnement technico-économique international dans lequel cette branche s'est développée en Inde et en République de Corée. L'industrie de ces pays fait ensuite l'objet d'un examen détaillé. Pour finir, la performance des industries nationales et les facteurs qui la déterminent sont comparés à la lumière de l'environnement international. L'industrie de la République de Corée est considérée comme plus avancée que celle de l'Inde, même si, eu égard à certaines différences au niveau des objectifs poursuivis, la stratégie indienne de développement pourrait se révéler judicieuse.

Emploi et relations interindustrielles verticales au Bangladesh

Dilip Kumar Roy

Les techniques de l'analyse entrées-sorties sont utilisées dans cet article pour mesurer les effets en amont et en aval des emplois créés par les industries manufacturières du Bangladesh. Il s'agit de déterminer les industries offrant de nombreuses possibilités d'emploi, l'emploi étant parmi les principales préoccupations du gouvernement. L'auteur conclut que les branches ci-après revêtent à cet égard une importance primordiale : thé, textiles de coton et de jute, papier, produits pharmaceutiques, divers produits chimiques, bois et autres produits manufacturés (spécifiés dans l'article).

Quelques observations sur l'estimation des paramètres économiques nationaux de la Jamaïque

John Weiss

L'article examine quelques-unes des questions soulevées par une étude assez vaste ayant pour objet l'estimation des paramètres économiques nationaux de la Jamaïque. Il est divisé en deux parties : la première traite de quelques points pratiques intéressant les procédures d'estimation, et notamment l'application d'un facteur moyen de conversion à l'échelle de l'économie tout entière, les principaux secteurs dont les produits n'entrent pas dans le commerce international et le salaire fictif de la main-d'oeuvre non qualifiée. La seconde partie traite de points plus théoriques soulevés par l'étude, dont la mesure dans laquelle la méthodologie des prix fictifs implique une distorsion vers le libre-échange; le problème posé par la prise en compte des variations des taux de change; et la définition d'un taux d'actualisation. L'article cherche à cerner quelques-unes des difficultés que soulève l'utilisation des prix fictifs pour l'analyse détaillée d'une économie comme celle de la Jamaïque, et conclut qu'en dépit de ses insuffisances cette approche peut servir de complément à d'autres méthodes de planification.

Développer l'industrie locale des pays en développement grâce aux "centres d'études industrielles" relevant d'organismes de services

Peter B.U. Achi

Les pays en développement éprouvent le souhait légitime de se doter d'une économie industrielle stable. Bien qu'ils ne puissent point ignorer le niveau de technologie industrielle des pays développés, ils savent désormais fort bien que c'est de leurs propres efforts que dépend la constitution d'une économie industrielle stable. L'article qui analyse principalement (mais non exclusivement) l'expérience nigériane, traite de la contribution que les centres d'études industrielles apportent à la formation d'une main-d'oeuvre industrielle indispensable pour la croissance rapide des pays en développement. Axés sur les activités de liaison et de formation orientées vers des projets industriels ainsi que sur la commercialisation des produits locaux, ces centres font notamment appel à d'anciens étudiants comme entrepreneurs.

EXTRACTO

Las industrias de circuitos integrados de la India y la República de Corea consideradas en un contexto tecnoeconómico internacional

Charles Edquist y Staffan Jacobsen

La India y la República de Corea han adoptado estrategias muy diferentes para desarrollar la capacidad nacional de producción de circuitos integrados, esfera de la alta tecnología generalmente dominada por productores de países desarrollados. Tras una breve descripción de los circuitos integrados, el estudio proporciona un panorama global de esta industria a fin de determinar el contexto tecnoeconómico internacional en que se han venido desarrollando las industrias de la India y la República de Corea. Luego se examinan en detalle los diversos aspectos de esta industria en ambos países. Por último, se compara su respectivo rendimiento, y los factores determinantes conexos, en el contexto internacional. Se desprende que esta industria está más avanzada en la República de Corea que en la India, aunque dadas las diferencias entre los objetivos de ambos países, la estrategia de desarrollo de la India podría resultar apropiada.

Vinculaciones entre el empleo y la industria en Bangladesh

Dilip Kumar Roy

En este artículo se utilizan las técnicas del análisis insumo-producto a fin de medir los efectos de concatenación regresiva y progresiva del empleo sobre las industrias manufactureras de Bangladesh. Dado que el empleo es una preocupación primordial del Gobierno, el estudio tiene por objeto determinar las industrias con un alto índice de generación de empleo total. El autor concluye que las industrias generadoras de empleo que tienen importancia prioritaria son las del té, textiles de algodón y yute, papel, productos farmacéuticos y otros productos químicos, madera, y otras industrias manufactureras (enumeradas en el artículo).

Algunas observaciones sobre la estimación de parámetros económicos nacionales para Jamaica

John Weiss

En este estudio se examinan algunas de las cuestiones planteadas en otro estudio más amplio respecto de estimación de parámetros económicos nacionales para Jamaica. El estudio consta de dos secciones. En la primera se examinan algunas cuestiones de carácter práctico relacionadas con los procedimientos de estimación. Se incluye un análisis del tratamiento de un factor de conversión medio aplicable a la economía en su conjunto, así como de los principales sectores no comerciales y del salario sombra de la mano de obra no

calificada. En la segunda sección se tratan cuestiones de carácter más teórico planteadas en el estudio anterior, entre las que se cuentan las siguientes: la medida en que la metodología aplicada al precio sombra contiene un sesgo implícito con respecto al libre comercio; el problema de los reajustes en función de las fluctuaciones de los tipos de cambio; y la definición de la tasa de actualización. En este estudio se tratan de determinar algunas de las dificultades que presenta la aplicación del análisis detallado de los precios sombra en una economía como la de Jamaica; sin embargo, se llega a la conclusión de que, pese a sus limitaciones, ese enfoque puede complementar en forma provechosa otros métodos de planificación.

<u>Desarrollo de la industria local a través de "centros de estudios industriales" en instituciones terciarias de países en desarrollo</u>

Peter B.U. Achi

Los países en desarrollo desean, con toda razón, establecer economías industriales sólidas. Si bien no pueden hacer caso omiso del nivel de tecnología industrial alcanzado por los países desarrollados, hoy día es evidente que el desarrollo de economías industriales estables dependerá de los esfuerzos de los propios países en desarrollo. Tomando principalmente (aunque no exclusivamente) a Nigeria como ejemplo, en el artículo se examina el enfoque de la formación industrial centrado en la creación de "centros de estudios industriales" para el logro de un crecimiento rápido en los países en desarrolo. Estos centros se ocupan principalmente de las vinculaciones y la capacitación en el sector industrial en el marco de proyectos concretos, así como de la comercialización de productos locales recurriendo en parte a empresarios que han asistido ya a los centros.

INFORMATION FOR CONTRIBUTORS

The Supervisory Panel of *Industry and Development* welcomes contributions relevant to the stated aims and scope of the journal. Authors should contact the Supervisory Panel at the address given below.

1. Articles may be submitted in English, French or Spanish to:

   Supervisory Panel of *Industry and Development*
   Studies and Research Division, UNIDO
   P O. Box 300
   A-1400 Vienna, Austria

2. Articles submitted should contain original, unpublished work not being considered for publication elsewhere.

3. The Supervisory Panel does not accept responsibility for loss of manuscripts.

4. Two copies of the manuscript should be submitted. It should be typewritten in double spacing on white bond paper, and all pages should be numbered consecutively.

5. The first page of the manuscript should contain the title, the name and institutional affiliation of the author, a summary of the article not exceeding 100 words, and the current address of the person to whom proofs may be sent.

6. Mathematical expressions should be numbered throughout the manuscript. If a derivation has been abbreviated, the full derivation should be presented on a separate sheet, which will not be published. The use of complex mathematics should be kept to a minimum.

7. Footnotes should be numbered consecutively throughout the text. References should include complete bibliographical data: author, full title of paper (or book), publisher, and place and date of publication. A reference to an article published in another journal should include that journal's full title, as well as the place and date of publication, author, volume number, issue number and page numbers. See a current issue of *Industry and Development* for the style employed for footnotes and references.

8. Illustrations and tables should be numbered consecutively throughout the text and provided with clear captions and labels.

9. Fifty offprints of their articles will be made available to authors.

10. Authors should note that, in accordance with UNIDO publications policy, articles accepted for publication are subject to editorial review by the UNIDO Secretariat.

Printed in Austria
V.86-60276—May 1987—4,000

01500P

UNIDO publication
Sales No.: E.87.II.B.1
ISBN 92-1-106220-9
ISSN 0250-7935
ID/SER.M/21