Electronics Development Strategy
The Role of Government

June 1990
ELECTRONICS DEVELOPMENT STRATEGY

THE ROLE OF GOVERNMENT

Carl J. Dahlman

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EXECUTIVE SUMMARY

i. This paper is a brief overview of the role of government in the development of the electronics sector in four developed economies (U.S., U.K., France, and Japan) and seven developing economies (Brazil, China, India, Korea, Taiwan, Singapore, and Hong Kong).

ii. The principal rationale for government involvement in the development of electronics is that electronics is a key input into many other areas of economic activity and therefore has the potential for spurring economic progress across a broad front. It is also considered to be a strategic input in advanced defense, and in a broad sense, a base for national economic strength and international competitiveness. This paper does not examine the validity of this rationale. Rather, it focuses on how governments have fostered the development of their electronics sector and—based on a comparison of the results—attempts to draw some conclusions and policy recommendations for developing countries.

iii. The main governmental instruments used for promoting the development of the electronics sector include:

- direct participation through state enterprises
- trade protection
- publicly financed research and development (R&D)
- fiscal and financial incentives for industrial R&D or establishment of firms
- government procurement
- regulation of direct foreign investment
- industrial organization instruments to prevent monopoly or to encourage concentration to increase international competitiveness, and
- development of technical human resources.

iv. Section III of the paper briefly summarizes the extent to which these instruments have been used, in order to characterize the role of government in the eleven economies reviewed (Table 1). This characterization of the different strategies includes: specific targeting; direct state participation and mix between private local and foreign control; the narrowness or breadth of the targeted sector; sequencing in moving from one subsector to another; and focus on domestic versus foreign markets (Table 2).

v. The final section focuses on the developing economies as well as on Japan, due to its relatively recent transition to developed country status. It concludes that the most successful performers in developing an internationally competitive electronics industry have been Japan, Korea, and Taiwan. Although they have tended to rely on the private sector, the state has played an important role as coach, father, nurturer, respectively. Hong Kong, the most laissez faire case, also has been successful, although limited primarily to simple consumer electronic goods and computers. Singapore also has succeeded in building a large, rapidly growing export-oriented sector by relying very heavily on foreign capital and know-how. The least successful, in terms of international competitiveness, have been India and China. Part of the reason for their relatively poor performance appears to have been their excessively autarkic approach until very recently, and to the very heavy state presence in the sector. Brazil's performance is between that of China/India and the East Asian Newly Industrialized Economies (NIEs), though closer to the former than to the latter. Brazil's relatively poor performance is due to excessive protection of national firms, too much restriction of foreign capital in telecommunications and computers, and heavy emphasis on regional development rather than economic objectives, in the case of consumer electronics.
Several lessons emerge from the experiences reviewed.

- Key aspects of a successful industrial strategy in electronics appear to be some protection and nurturing during the initial phase of development, while demanding improved performance by forcing firms to compete abroad and at home.

- A focus on export markets is important not only for competitive pressure but to achieve economies of scale and increase the dynamic learning associated with exports.

- Continuous access to foreign technology is critical because technology is changing so quickly and because no country can be fully autonomous in technology.

- It is important to be selective in targeting electronics subsectors because it is difficult to develop the whole sector simultaneously.

- A healthy macroeconomic environment with prospects for growth, and flexibility in capital and labor markets to be able to adapt to changing conditions, also appear to be important.

- The role of the government changes as the sector and the economy mature.

- The electronics industry should not be viewed as an end in itself but as a means to increased efficiency and competitiveness.

- Governments have not succeeded alone. Success has depended on many other factors, including the level and quality of human resources, the quality of the supporting technological infrastructure, and the dynamism and quality of management and entrepreneurship in the private sector.

Four key roles of the state emerge for the successful development of the electronics sector. The first is to develop appropriate technical human capital to take advantage of the opportunities that arise from rapid technical change in electronics. The second is to strengthen the basic technological infrastructure, including access to technological information, basic metrology and standards, and some degree of research infrastructure to help industry assess the relevance of recent advances and to acquire and use technology. The third is to provide the right incentive regime to stimulate firms to improve their technological levels. The fourth is to provide an environment for flexible adjustment of the production structure, which is particularly important in electronics because of the dynamism of the sector.

Finally, the paper identifies some remaining issues which require further work. These include:

- the desirability or appropriateness of targeting,

- the advantages of sequencing versus leapfrogging in developing the sector,

- the extent to which a strong export orientation will continue to be feasible for various countries in light of the possible closing of traditional export markets if the trend toward regional trading blocks continues, and

- the degree to which access to new technology may become more difficult in light of the greater emphasis being given to intellectual property rights.
I. INTRODUCTION

1.01 This paper provides an overview of the role of government in developing the electronics sector in four developed and seven developing countries and summarizes some lessons from their experiences. Government has been actively involved in the development of the electronics sector in all the economies examined except Hong Kong. This involvement has taken different forms with different degrees of success, which gives rise to a number of questions.

1.02 How successful have the different governments been in accomplishing their objectives? To answer this, government objectives must be identified clearly and sufficient information assembled to judge whether those objectives have been met. This is complicated because of the multiplicity of objectives, some of which may be in conflict. For example, it is not possible to have a technologically independent industry that is also internationally competitive. The high costs of developing technology and the speed of technical change mean that no country can be a technological leader in all areas. Although some countries--India and China until recently--were autarkically oriented, even they have recognized that to be internationally competitive, it is necessary to make use of foreign technology.

1.03 How effective have different government strategies been in increasing the competitive performance of the electronics industry? Though this question is narrow, it is difficult to measure performance--because performance can vary over time as firms learn better production. Moreover, technology and best practice change over time, making performance not an absolute concept but a relative one.

1.04 A third question concerns the cost at which competitiveness is achieved. This is difficult to judge because it is necessary to examine not only the direct costs of using public funds for research and investment but also the opportunity cost of those funds and--to the extent that protection exists--the additional costs to consumers of more costly, protected products. This area also involves intertemporal issues and the social rate of time discount. Moreover, cost assessment is complicated further because performance is a "moving target", so to speak. Learning may occur for the protected product, but better products based on different technologies may be developed, and the learning that occurred in producing the first product may not be transferable to the production of the second.

1.05 Section II outlines the main rationales for government attention to developing the electronics industry. It also describes possible roles of government and some common instruments and strategies. Section III characterizes the strategies and instruments used in each country and provides comparative data on the size, nature and importance of the sector across countries as of 1987. The final section draws some general conclusions and policy implications for developing countries.
II. FRAMEWORK

A. Rationale for Government Involvement

2.01 Strategic sector. Many different rationales have been invoked by governments for their involvement in developing the electronics sector. Because of its rapid growth and increasing importance as an input into many other areas of economic activity, electronics is considered a key sector of industry. This is because electronics has the potential for directing economic progress across a broad front, much as the development of steam power and electricity did many decades ago. Electronics also is considered to be of strategic importance, in a narrow sense, as a critical input in advanced defense, and in a broader sense as a critical base for national economic strength and international competitiveness. Thus, the rationales for government support of the sector are particularly related to the perception of electronics as strategic rather than just a leading industry.

2.02 Military and commercial objectives. Various governments have emphasized the military over the commercial as a rationale for the strategic importance of the electronics sector. The U.S. traditionally has put the most emphasis on the military rationale; the U.K., France, Brazil, China, and India have followed suit. Japan, Korea, Taiwan and Singapore have emphasized developing the electronics sector for industrial competitiveness. However, while these objectives have had some influence on how the electronics sector has been promoted in various countries, most instruments for promoting electronics development are common to both the military and commercial approaches.

B. The Role of Government

2.03 Three different dimensions of the role of government in promoting a sector should be made explicit. The first involves government programs and actions directly targeting the promotion of a selected industry, in this case the electronics industry, or even products. This targeting can be accomplished through a wide range of instruments.

2.04 The second dimension is more generic: functional targeting of activities such as research and development, investment and technical education. Although these activities are not sector specific, they can have an important indirect, promotional effect to the extent that some industrial subsectors have a greater need for subsidized inputs. The electronics industry, for example, with its very heavy research and science and engineering intensity, indirectly receives preferential promotion through a country's general incentives for industrial R&D or for technical higher education. The more capital-intensive segments of the electronics sector also indirectly receive preferential promotion from industrial incentives or allowances such as accelerated depreciation and other tax write-offs.

2.05 The third dimension is the quality of macroeconomic management and the degree to which appropriate policies and institutions permit flexible adjustment in capital and labor markets to changing conditions. This role of government often is overlooked in discussions of industrial policy, but there is mounting evidence that it can be critical to structural change and competitiveness. This is particularly relevant to the electronics industry because of the very rapid pace of technical change, as well as the global nature of its market, and its high degree of international competition.

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1/ This distinction between leading and strategic is based on Nelson, 1984.

C. Main Instruments and Strategies

2.06 The main governmental instruments for promoting development of the electronics sector include:

- Direct participation in the sector through state enterprises
- Trade protection, export promotion and export performance requirements
- Publicly-financed research and development carried out in public R&D laboratories, universities, and firms
- Fiscal and financial incentives for industrial R&D in the sector, for establishment of firms in the sector, and for purchasing the sector's products
- Government procurement guarantees for specific products
- Regulation of direct foreign investment in the sector
- Industrial organization instruments that can be either antitrust-oriented, to prevent concentration and encourage licensing; or pro-concentration, to promote concentration and large holdings, and
- Development of technical human resources

2.07 These instruments can be used in varying degrees depending on the extent of government commitment to the sector and its sector development strategy. Five key elements of government strategy are the:

- Degree of specific targeting in the sector
- The mix between private and public, and local and foreign, participation in the sector
- Narrowness or breadth of the targeted sector
- Sequencing, if any, in moving from one segment of the electronics subsector to another, and
- The focus on domestic vs. markets—including the sequencing of entry into each
III. COUNTRY EXPERIENCES

3.01 The eight instruments of government action used across selected countries are provided in Table 1.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>low</td>
<td>low</td>
<td>high</td>
<td>low</td>
<td>high</td>
<td>low</td>
<td>anti</td>
</tr>
<tr>
<td>U.K.</td>
<td>medium</td>
<td>low</td>
<td>high</td>
<td>medium</td>
<td>high</td>
<td>low</td>
<td>pro</td>
</tr>
<tr>
<td>France</td>
<td>high</td>
<td>medium</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>pro</td>
</tr>
<tr>
<td>Japan</td>
<td>low</td>
<td>high*</td>
<td>medium</td>
<td>high</td>
<td>high</td>
<td>medium</td>
<td>pro</td>
</tr>
<tr>
<td>Brazil</td>
<td>medium</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>neutral</td>
</tr>
<tr>
<td>China</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>pro</td>
</tr>
<tr>
<td>India</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>anti</td>
</tr>
<tr>
<td>Korea</td>
<td>low</td>
<td>high h/</td>
<td>high*</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>pro</td>
</tr>
<tr>
<td>Taiwan</td>
<td>medium</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>medium</td>
<td>anti</td>
<td>high</td>
</tr>
<tr>
<td>Singapore</td>
<td>medium</td>
<td>low</td>
<td>medium</td>
<td>low</td>
<td>neutral</td>
<td>low</td>
<td>neutral</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>low</td>
<td>low</td>
<td>low</td>
<td>low</td>
<td>low</td>
<td>low</td>
<td>neutral</td>
</tr>
</tbody>
</table>

Notes: * In early period
h/ Very restrictive in minicomputers, and some in telecom, not in other sectors.

3.02 The countries' reliance on each of the five main strategic approaches--targeting, ownership control, broad support, sequencing, and market-oriented moves--are highlighted in Table 2.

3.03 Several clarifications are in order before delving into the country experiences. First, over time the role of government and the relative importance of different instruments have differed within as well as across countries. Second, the electronics sector involves several segments, and the strategies and instruments used in each have very often been different. The tables merely summarize the role of government in a general way. The sections on each of the countries, which follow below, add nuances.

A. The United States--The State Obsessed with Defense but Without a Plan for the Private Sector

3.04 The U.S. government has targeted heavy financing toward R&D in electronics. The initial development of the electronics sector in the U.S. was very much led by the Department of Defense (DOD). Government contract research and procurement related to defense have been perhaps the most important direct U.S. government influence on the development of the sector, particularly semiconductors.

3/ An example of a successful DOD program was the spinoff from the Minuteman missile system in the 1950s, which funded Texas Instruments' research on integrated chips and helped set up Motorola. In the 1960s, the whole development of C-MOS and N-MOS came from NASA programs.
### Table 2: Characterization of Government Strategies

<table>
<thead>
<tr>
<th>Targeting</th>
<th>Control</th>
<th>Breadth</th>
<th>Sequencing</th>
<th>Market Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S</td>
<td>low</td>
<td>private</td>
<td>broad</td>
<td>unplanned</td>
</tr>
<tr>
<td>U.K</td>
<td>medium</td>
<td>state/private</td>
<td>broad</td>
<td>unplanned</td>
</tr>
<tr>
<td>France</td>
<td>high</td>
<td>state/private</td>
<td>broad</td>
<td>sequenced</td>
</tr>
<tr>
<td>Japan</td>
<td>high</td>
<td>private</td>
<td>broad</td>
<td>sequenced</td>
</tr>
<tr>
<td>Brazil</td>
<td>high</td>
<td>state/private/foreign</td>
<td>semi-broad</td>
<td>unsequenced</td>
</tr>
<tr>
<td>China</td>
<td>high</td>
<td>state/some foreign</td>
<td>semi-broad</td>
<td>unsequenced</td>
</tr>
<tr>
<td>India</td>
<td>high</td>
<td>state/private</td>
<td>semi-broad</td>
<td>unsequenced</td>
</tr>
<tr>
<td>Korea</td>
<td>medium</td>
<td>private</td>
<td>broad</td>
<td>sequenced</td>
</tr>
<tr>
<td>Taiwan</td>
<td>high</td>
<td>state/private</td>
<td>broad</td>
<td>sequenced</td>
</tr>
<tr>
<td>Singapore</td>
<td>medium</td>
<td>foreign/state</td>
<td>narrow</td>
<td>sequenced</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>low</td>
<td>foreign/private</td>
<td>narrow</td>
<td>unplanned</td>
</tr>
</tbody>
</table>

Notes: g/ Except for emphasis on defense. h/ But higher in the past than now. i/ State strong in telecom, mini-computers; foreign strong in large computers, consumer electronics. j/ Very little foreign. k/ Very little local private.

#### 3.05 Trade Protection

Trade protection has not been very important in the U.S. electronics industry. In the 1970s the U.S. negotiated import quotas on TVs from Japan, Taiwan, and South Korea. In 1986 it negotiated a semiconductor agreement with Japan. No specific fiscal and financial incentives for R&D, special investment incentives, or guaranteed government purchase of electronics products, except for defense orders, exist.

#### 3.06 Industrial Policy

Although other countries' industrial policy has been used to promote mergers and consolidations to increase international competitiveness of their electronics industry, the U.S policy has focused on antitrust enforcement to prevent domestic monopolies and to facilitate the licensing of technology.

A prime example is the consent degree of the 1956 that confined AT&T to the telephone business and forced it to license its semiconductor technology to third parties. This decision prevailed until 1981—when AT&T itself was broken up and thereafter permitted to engage in the computer business outside of telecommunications.

4/ Direct foreign investment restrictions in the U.S. have been limited to a few cases. For example, in the proposed acquisition of Fairchild Industries by a Japanese company, it was argued that Fairchild's products were vital for national security.
### Table 3: AGGREGATE ELECTRONICS DATA 1987

(Billion US$)

<table>
<thead>
<tr>
<th>Country</th>
<th>Imports</th>
<th>Exports</th>
<th>Production</th>
<th>Market</th>
<th>GDP</th>
<th>Prod-GDP (in percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>53.5</td>
<td>35.6</td>
<td>184.8</td>
<td>202.6</td>
<td>4,497.2</td>
<td>4.11</td>
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<td>U.K.</td>
<td>18.1</td>
<td>14.6</td>
<td>23.9</td>
<td>27.5</td>
<td>575.7</td>
<td>4.16</td>
</tr>
<tr>
<td>FRANCE</td>
<td>14.5</td>
<td>10.9</td>
<td>25.4</td>
<td>29.1</td>
<td>873.4</td>
<td>2.91</td>
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<tr>
<td>JAPAN</td>
<td>7.7</td>
<td>58.5</td>
<td>148.3</td>
<td>97.5</td>
<td>2376.4</td>
<td>6.24</td>
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<tr>
<td>BRAZIL</td>
<td>0.8</td>
<td>0.7</td>
<td>5.6</td>
<td>5.7</td>
<td>299.2</td>
<td>1.86</td>
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<tr>
<td>CHINA b)</td>
<td>1.7</td>
<td>0.1</td>
<td>5.4</td>
<td>7.2</td>
<td>274.6</td>
<td>1.86</td>
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<td>INDIA</td>
<td>0.6</td>
<td>0.1</td>
<td>3.1</td>
<td>3.5</td>
<td>220.8</td>
<td>1.38</td>
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<td>KOREA</td>
<td>4.4</td>
<td>9.8</td>
<td>13.3</td>
<td>7.9</td>
<td>121.3</td>
<td>10.98</td>
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<td>SINGAPORE</td>
<td>6.6</td>
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<td>7.5</td>
<td>4.0</td>
<td>19.9</td>
<td>37.87</td>
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<td>3.9</td>
<td>9.1</td>
<td>11.0</td>
<td>5.3</td>
<td>94.3</td>
<td>11.66</td>
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<tr>
<td>HONG KONG</td>
<td>7.5</td>
<td>9.2</td>
<td>5.3</td>
<td>3.6</td>
<td>36.5</td>
<td>14.53</td>
</tr>
</tbody>
</table>

Notes:  

b) Electronics includes electronic data processing, office equipment, control instrumentation, medical and industrial, communications and military, telecommunications, consumer electronics, and components. See Table 4 for breakdowns by country and type of product.

Data for China is for 1983.


### Table 4: PERCENTAGE BREAKDOWN OF ELECTRONICS PRODUCTION 1987

<table>
<thead>
<tr>
<th>Country</th>
<th>EDP</th>
<th>Office Equip.</th>
<th>Control Instrumentation</th>
<th>Medical &amp; Industrial</th>
<th>Consumer Electronics</th>
<th>Component</th>
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<td>26.9</td>
<td>3.2</td>
<td>11.5</td>
<td>3.7</td>
<td>23.9</td>
<td>8.8</td>
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<td>U.K.</td>
<td>30.8</td>
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<td>3.6</td>
<td>16.1</td>
<td>11.0</td>
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<td>23.3</td>
<td>1.4</td>
<td>8.0</td>
<td>2.4</td>
<td>24.9</td>
<td>18.5</td>
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<td>3.6</td>
<td>2.8</td>
<td>5.3</td>
<td>7.7</td>
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<td>1.3</td>
<td>5.5</td>
<td>10.4</td>
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<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>INDIA</td>
<td>7.6</td>
<td>1.6</td>
<td>7.8</td>
<td>2.1</td>
<td>12.6</td>
<td>12.3</td>
</tr>
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<td>KOREA</td>
<td>11.0</td>
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<td>0.6</td>
<td>1.8</td>
<td>8.1</td>
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<td>SINGAPORE</td>
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<td>2.3</td>
<td>0.5</td>
<td>1.2</td>
<td>2.0</td>
</tr>
<tr>
<td>TAIWAN</td>
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<td>0.7</td>
<td>0.8</td>
<td>4.3</td>
<td>8.0</td>
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<td>HONG KONG</td>
<td>16.1</td>
<td>4.8</td>
<td>1.4</td>
<td>1.5</td>
<td>9.2</td>
<td>6.6</td>
</tr>
</tbody>
</table>

3.07 Perhaps the most important role of the U.S. government has been its heavy investment in higher and technical education since World War I, which put the U.S. far ahead in science and technology until the late 1970s and early 1980s when other countries, most notably Japan, began to catch up. However, that heavy investment in technical education did not specifically target electronics.

3.08 With the exception of Hong Kong, and excluding the military sector, the U.S. has had the least directly interventionist policy for developing the electronics sector. Maintaining this strategy has been possible due to the early spinoff of electronics from the military, the huge size of the electronics subsector, the high science and technology base with abundant technical personnel, the dynamic private sector, and very flexible capital and labor markets. The large domestic market and the flexibility of capital and labor markets have been essential for the start-up of many innovative firms. Many are spinoffs by personnel who worked for larger established firms or research facilities and were been able to raise capital through the active U.S. venture capital market.

3.09 To some extent the uncoordinated approach in the U.S. has been a reflection of an underlying philosophy that industrial planning is not the role of government. However, in the last few years concern in the U.S. has been growing that the government must devise a more activist policy if the U.S. is to stay ahead of its strong competitors, Japan and the European Community. This new approach—-for more government coordination—-is reflected in changes in antitrust policy and the creation of various research consortia, as well as in the current debate about government support for a program to develop high-definition television (HDTV).

3.10 The National Cooperative Research Act of 1984 relaxed enforcement of antitrust prohibitions for interfirm collaboration in pre-commercial research. This facilitated the establishment of the Microelectronics Computer Corporation (MCC), SEMATECH, and other research consortia. MCC is a consortium of 20 U.S. computer and semiconductor manufacturing firms to explore technologies that will be used in the next generation of computers. However there have been problems in getting its member firms to cooperate. MCC has also been criticized for potentially reducing the number of technological alternatives pursued by independent firms, traditionally one of the powerful forces for innovation and growth of the industry.

3.11 MCC is a private consortium, but the government has taken a direct role in SEMATECH, a research consortium of 14 U.S. producers of microelectronic components. DOD is contributing $600 million in matching funds to this research consortium over six years. (Mowery and Steinmuller, 1990). DOD believes that U.S. suppliers of defense components cannot survive without a strong presence in commercial markets and that they need research subsidies to support commercial technology development. The consortium is closed to non-U.S. firms, which is an embarrassment when U.S. firms want to join similarly restricted consortia in Europe. Unlike the Japanese cooperative research efforts, which tend to focus on the development of generic pre-commercial technologies, SEMATECH'S objective is to develop advanced commercial production technology for standard integrated chips (ICs) such as dynamic random access memories (DRAMs). However, many doubt how

5/ See Flamm, 1987 for an extensive analysis of the role of government in the development of computers in the U.S., Japan, and Europe.

6/ Venture capital was most important during the 1960s and 1970s. It was gradually supplemented by public offerings relying on the large U.S. capital market.

7/ Its budget is about $60 million a year.

8/ See Mowery and Steinmuller (1990)

9/ Three government agencies also participate in the Semiconductor Research Corporation (SRC) which is the semiconductor industry's research consortium. SRC funds silicon based research in universities in order to ensure sufficient graduates with skills that can be used by U.S. industry.
effectively the competing U.S. firms will cooperate to develop commercial technology that is to be shared by all
the members of the consortium.10

3.12 Proponents of a greater government role in supporting HDTV appear to have received a
setback because of the lack of support from the Bush administration. However, pressures for a greater
government role in supporting the electronics industry continue to be strong, and it is likely that new initiatives
will be passed. These stem from the rapid fall in preeminence of the U.S. in the world electronics industry in
the last few years. Flamm (1990), for example, has shown that the U.S. share of world production of the
consumer, industrial, and components segments of electronics fell from 13.5%, 55.3%, and 45.9% respectively
in 1985, to 7.8%, 41.7%, and 33.5% in 1988.

3.13 The U.S., however, still has the largest electronics sector and market (Table 3). Its electronics
sector consists of more than 18,000 firms and employs more than 1.7 million people.11 Its leading segments are
electronic data processing equipment--especially large computers, communications and military electronics.
Medical and industrial electronics also account for a greater share of U.S. production than in other countries
(Table 4). Conversely, the U.S. has the smallest share of production in consumer electronics; other countries,
particularly Japan and the East Asian NlEs, have overtaken the U.S. in the consumer electronics segment. The
U.S. has the lowest ratio of exports to production among the developed countries since the U.S. is the world's
largest market and since it has begun to lose competitiveness in many less sophisticated electronics products.

B. Japan--The State as Private Sector Coach and Coordinator

3.14 In Japan the role of government in developing the electronics sector is quite different from the
role of government in the U.S., U.K., or France. The Japanese government has constantly worked to identify
and eliminate bottlenecks impeding continued progress--and to provide a national vision of future possibilities.
This has been done within a framework of active consultation with the private sector, with actions directed at
supporting and strengthening the private sector rather than supplanting it. Another special characteristic has
been the government's many carefully coordinated support policies: trade and foreign investment protection,
support for research and development through conditional loans and consigned payments, and encouragement
of appropriate market structures.

3.15 Tariffs, quotas and other trade barriers were used extensively in the 1960s and early 1970s to
protect the development of computers and semiconductors.12 These restrictions were used to bargain for access
to foreign technology. Starting in 1972, quotas and restrictions on foreign investment and technology tran...
were gradually relaxed. By 1976 trade and investment in computers were completely liberalized. Today computer tariffs in Japan are lower than European tariffs but slightly higher than in the U.S.\(^{15}\)

3.16 In the early 1950s and until 1960, research on computers was carried out mainly in government laboratories \(^{14}\) since private, corporate R&D labs scarcely existed. In 1960, when IBM was allowed to set up production in the local market, the government launched a five-year plan to produce Japanese computers. In support of the plan, the government raised import barriers and required access to foreign technology as the admission price for foreign firms to enter the local market. \(^{16}\) From then on, the Ministry of Trade and Industry (MITI) played a vigilant role supporting the development of local industry in response to advances made by IBM. \(^{17}\)

3.17 Government support for research and development was large relatively to private industry's own R&D efforts in the early 1960s. In the early 1970s, MITI shifted its funding toward joint research associations. In 1974, when MITI's funding reached a peak of 25% of all funds for computer research, nearly half of total computer research in Japan was done in joint research associations. Beginning in 1978, private R&D took off dramatically, and although the level of MITI funding remained more or less constant, by 1984 it was only 4% of the total. However, Nippon Telegraph and Telephone (NTT) has become a more important research funder then MITI, accounting for about one-fifth the total in 1984, most of that with private firms. \(^{18}\)

3.18 Through MITI, the government also has influenced market structure to improve Japanese competitiveness. For example, when IBM launched its 370 System in the early 1970s, it knocked computer companies such as GE, RCA, and Xerox--which had been the foreign partners for some of the Japanese computer companies--out of the field. MITI's response was to consolidate six independent computer producers into three groups and increase funding for research and product development. Collusion among Japanese electronics firms has not appeared to be a problem. In fact, fierce competition among firms has tended to be the problem, which often has undermined the collaborative experiments promoted by MITI, including the above-mentioned rationalization. However, MITI has been successful in playing the coordinating role, especially in fostering cooperative precompetitive research through its financial incentives to joint research associations.

3.19 Japan also has used tax and loan policies as an explicit instrument of industrial policy to promote the computer industry. Tax benefits favor R&D and exports from all producers in general, but special tax benefits accrue to computer producers and users alike; these benefits are fine-tuned every two to five years.

\(^{13}\) Flamm, 1987, pp. 152-153.

\(^{14}\) MITI's Electrotechnical Laboratory (ETL), National Telephone and Telegraphs' (NTT) laboratory, and those in national universities.

\(^{15}\) For example, IBM had to license some of its technology and limit its sales in the Japanese market. However, IBM remained the largest computer company in Japan until it was surpassed by Fujitsu in 1981.

\(^{16}\) Japanese companies such as NEC and Hitachi formed joint ventures with foreign firms. Only Fujitsu decided to develop computer technology on its own, and it became the head of the first cooperative research association funded by MITI. In response to IBM's 360 System introduced in 1964, MITI organized the super high performance computer projects (SHP CP) that pooled resources of government labs and private corporations. In 1968 NTT also launched a major project called the DIPS information processing system computer which also involved contracting with local Japanese companies. During this period government support therefore came from its research labs as well as through conditional loans and consigned payment for contractual development of technologies by private firms.

\(^{17}\) Flamm, 1987, pp. 131-143.
Subsidized credit through the Japan Development Bank has also been important to the computer industry. One of the largest programs of subsidized credit was channeled through the Japan Electronic Computer Co. (JECC), set up with help from MITI in 1961 to buy locally-produced computers and lease them to users in competition with IBM's leasing program. At its peak in the late 1960s, JECC accounted for as much as 80% to 90% of Japanese shipments (excluding deliveries of foreign computers). MITI also helped establish the Japan Information Processing Development Center (JIPDEC) in 1967 to market software and provide training. Its activities eventually led to the so-called Fifth-Generation Computer Project.

3.20 An important Japanese program was the very large-scale integrated circuit (VLSIC) program of the late 1970s. This actually consisted of two programs: one designed by NTT to develop and procure ICs for telecommunications, the other designed by MITI to bring Japanese companies to state-of-the-art generic technology for computer ICs. The salient features of the MITI project were its organization around several corporate R&D labs and its joint funding by the companies and MITI. A more recent program is the fifth-generation project. This is a ten-year endeavor financed in part from consigned research grants from MITI to develop a new computer architecture for symbolic computing and artificial intelligence. This program provoked widespread reaction in the U.S. and Europe.

3.21 Japan is second only to the U.S. in electronics production but is the world's largest exporter. The electronics sector consists of about 18,000 companies employing over 1.2 million workers. Although components account for the largest share of Japanese production, consumer electronics account for the largest share of its electronics exports. Japan dominates world markets in VCRs and other advanced consumer electronic products. In terms of its production structure, unlike the other developed countries, the largest subsector is components rather than electronic data processing, which is second. Moreover, its consumer electronics subsector, which is third, is much larger than in other developed countries. Conversely, reflecting Japan's limited thrust into defense applications, the communications and military subsector is the smallest among the developed economies and even among the semi-continental developing countries such as Brazil, China, and India.

3.22 In summary, the Japanese strategy has been to consolidate its production, first in the simple areas such as consumer electronics, which it did in the 1950s (radios and B&W TVs) and 1960s (color TVs), then to move into computers and semiconductors. Initially the domestic market received protection but gradually opened up as the industry matured. However, Japan has the lowest ratio of imports of electronics products to size of domestic market (Table 3). In the case of computers and semiconductors, the government focused more on positive measures for investing in R&D and joint research than on protection alone. It also emphasized higher education in science and engineering; since the late 1970s Japan has been graduating more electronics engineers than the U.S. although it has only half the population of the U.S.

C. The United Kingdom—The Schizophrenic State Now Focusing on the Private Sector

3.23 The development of the electronics sector in the U.K. has been closely linked with defense. However—unlike the U.S.—the U.K. has experimented with various forms of direct intervention in developing electronics. Government R&D expenditures motivated by military needs have been heavily concentrated in electronics and telecommunications—almost one-third during the 1970s. Unlike in the U.S., electronics and

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18/ Flamm, 1987, p. 145.
19/ Nelson, 1984, p. 49.
20/ The U.S. reacted with the formulation of a DARPA strategic computer program, the U.K. with the Alvey program, and the European Community with the ESPRIT program.
3.24 In the U.K. trade policy has not been used much to protect local industry. However, government procurement has been used extensively to develop the national electronics industry, and the government has taken direct equity positions in some electronics companies. For example, in 1968 the government formed the computer firm ICL by promoting a series of mergers, supported by government financing and R&D aid, and promising public sector purchases of computers. Similarly, the government invested heavily in the firm INMOS in 1978 in an attempt to create a world-class semiconductor manufacturer. In addition, the government has developed various programs to stimulate the use of electronics technology in other sectors. Through the Microprocessor Applications Project (MAP) it funds up to 25% of the costs of product development in order for manufacturers to incorporate microprocessors into their products. Through the Microelectronics Industry Support Program (MISP), also started in 1978, it gives financial and other support to firms manufacturing integrated chips.

3.25 U.K. government funding for many of the state-invested firms, as well as for many technology application programs, has not been consistent, and the government has begun relinquishing its investments in some companies. This posture partly reflects an inconclusive internal debate as to whether it is necessary to have manufacturing capability in semiconductors as opposed to focusing only on applications. Because of stop-and-go policies, combined with a liberal DFI strategy, foreign firms have captured the major share of the U.K. market, except in the defense sector.

3.26 Among the four developed countries reviewed, the U.K. has the smallest share of electronics production and markets globally, although electronics production as a share of U.K. GDP is larger than in the U.S. or France (Table 3). The electronics sector consists of more than 350 medium-sized companies employing about 370,000 workers. These comprise a small number of indigenous firms such as GEC, Racal, Plessey, Ferranti and STC and most of the large world multi-nationals in electronics such as IBM and Philips. As in the U.S., the electronics data processing subsector is the largest, followed by communications and military applications. However, the segment in which the U.K. has the largest share is electronics control and instrumentation. The slow growth of electronics in England has been the result of government's stop-and-go support for it and the slow rate of economic growth in the U.K.

D. France--The State as Chief Architect and Planner

3.27 France has the most centralized and coordinated policymaking among advanced Western nations. As in the U.S., defense concerns have had a large role. The government role increased in 1964 when the U.S. refused to sell France large computers for the development of fusion weapons. At the same time, General Electric purchased Machines Bull, a faltering French computer manufacturer. This convinced the French government of the need to develop its own, independent computer industry. The result was a concerted thrust in computers, known as the Le Plan Calcul. The government merged two existing manufacturers to create CII, a public corporation that was built up to be a "national champion" and to compete internationally with IBM. The government poured massive funds into CII, provided export subsidies, protected it against competitors in

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22/ For example, 90% of the government orders for computers were given to ICL in the 1970s as way to help develop that firm. See OTA, 1983 p. 402.

the local market, and guaranteed domestic procurement. However, CII was not successful, and in 1975, when the failure of the Plan Calcul was evident, CII merged with Honeywell Bull.

3.28 The military's need for semiconductors led to the 1977 Le Plan des Composants, designed by the ministries of defense, industry, the postal service and the telecommunication company. Learning from the failure of Le Plan Calcul, this plan supported not one "national champion" but five firms—including three joint ventures with U.S. firms for the infusion of advanced technology. This plan appears to have been more successful in raising the level of French technology. The R&D portion of this plan supported work on very large-scale integrated chips (VLSICs) as well as microprocessor applications.

3.29 The French government also launched a major plan to advance development and applications of telecommunications and forced the sale of two foreign-owned telecommunication subsidiaries to the national, government-owned, Thompson group. Roughly half of the French electronics sector is state owned. France's Eleventh Five-Year Plan (1981-85) targeted electronics for special support, including research, nationalizing relevant firms, and massive investments in electronics by both public and private companies.

3.30 France currently has the largest telecommunications market in Europe. The telecommunications/military subsector underwent a major reorganization with the absorption by CGE of ITT's world-wide telecommunications business in 1986, followed by the takeover of Matra Ericsson by GGCT and the privatization of CGE in May 1987. More recently France has been trying to strengthen its position in consumer electronics. In 1987 Thompson acquired U.S. General Electric and RCA consumer electronics product divisions.

3.31 France has the third largest electronics production and market size among the four developed countries considered here but the lowest share of electronics production as a share of GDP. More than 750 electronics companies—including about 100 foreign firms—employ about 230,000 workers. Consistent with France's preoccupation with defense, the military segment has the largest share in French electronics manufacture—the share for military uses being the largest among the eleven countries reviewed in this paper (Table 4). The telecommunications share in France also is the largest among the eleven countries, partly reflecting the recent government push to develop telecommunications.

3.32 Before turning to the strategy of developing countries, a few comments on more general efforts taking place in Europe are in order. The perceived failure of many of the individual national programs in Europe to catch up with the U.S. and Japan has led to a proliferation of programs at the European Economic Community (EC) level. This began at the end of 1981 with the four-year Microelectronics Program (Regulation 3744/81) to stimulate R&D for production and testing equipment for very large-integrated circuit manufacture. This modest program did not succeed in closing the technology gap but laid the groundwork for similar, more ambitious programs (Howell et al. 1988).

3.33 The European Strategic Program for Research and Development in Information Technologies (ESPRIT) was launched in 1984. It is a ten-year program funded at $2.75 billion dollars and intended to close the EC's technological gap in information technology with the U.S. and Japan. The program is designed to stimulate pre-competitive R&D activities in information technology by supporting collaborative projects among

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24/ It is estimated that the government poured as much as .7 to 1.0 billion dollars into CII through 1982.

25/ Honeywell Bull was a descendant of Machines Bull after General Electric was bought out by Honeywell. With the merger, CII-HB became a majority-owned state company but was nationalized in 1982.

26/ This paragraph draws heavily on OTA, 1983 pp. 394-400.
governments, industries, and research centers in EC member states. By 1987 over 500 organizations had participated, and about half the projects funded are said to have had some positive results. In April 1988 a second phase was approved with funding of about $1.87 billion dollars. This phase is supposed to be more market driven and also to focus more on basic research (Palmintera, 1989).

Furthermore, in reaction to heightened European concerns of being left behind when the U.S. announced its plans to spend massive amounts for research on the Strategic Defense Initiative, the Europeans, led by French President Mitterand launched a initiative to increase European research. This lead to the establishment of the European Research Cooperation Agency (EUREKA) in 1985 to promote cooperation on technology research and development in the 19 countries representing the EC, EFTA, and Turkey. By 1986 72 projects budgeted at more than $3 billion dollars over a ten-year period had been adopted. Most of the projects are concentrated in microelectronics (Howell et al. 1988).

In addition, in 1987 the EC launched a program parallel to ESPRIT--the Research and Development Program in Advanced Communications Technology (RACE). RACE focuses on R&D that will lead to a standardized broad-band communications network in Europe. Its priority areas are electronic components, optical equipment and integrated optoelectronics, specialized communication software, and flat panel displays for terminals. The total research budget is expected to be about $2.3 billion, half funded by the EC, half by industry.

There are also various other EC-sponsored cooperative research programs that focus on electronics. The Basic Research in Industrial Technologies for Europe (BRITE) program funds research and development in industrial manufacturing technologies and advanced materials applications. As with most of the EC projects, BRITE requires participation from at least two member countries and funds half the total project costs. The rest has to be funded by industrial participants. Almost 400 projects were being funded in 1989, and BRITE’s budget for that year was about $585 million dollars (Palmintera, 1989).

Although the results of these programs are not yet apparent, and their total budgets are still a small fraction of the total budgets allocated to R&D in electronics in Europe, they do indicate the great emphasis that the European governments are giving to technology in general and electronics in particular. Furthermore, there are strong concerns that to the extent that the Europeans are not able to close the technology gap with the U.S. and Japan through subsidies to R&D, in the context of EC92 they may be more likely to resort to trade-related restraints to protect the local electronics industry. Indeed, the EC has already stipulated that the diffusion step in wafer fabrication has to be done within the EC for the product to be considered European. This local content requirement will make it more difficult for non-EC countries to export semiconductors to the EC.

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27/ The five designated areas are: advanced microelectronics, computer aided design manufacturing, software, office systems, and advanced information processing.

28/ Unlike ESPRIT, EUREKA is not an EC institution governed directly by the European Commission. It is governed by a weak secretariat the includes non-EC countries such as Sweden.

29/ Unlike the EC projects such as ESPRIT, they focus more on advanced development than on basic research, are more company directed, and have more flexible funding structures than the 50% grant typical of the EC projects.

30/ See Flamm (1990b) for more details.
E. Brazil--The State as Nationalist Leader with a Differentiated Approach

3.38 The Brazilian government has had a very strong role in developing all the key segments of electronics, although with a different approach towards each. A common element in the development of three segments--telecommunications, computers, and consumer electronics--is that trade policy has been used extensively to protect the local market and thus foster the development of local industry. The objectives and the instruments used have varied across the subsectors.

3.39 In telecommunications the objective has been to develop a strong domestic industry. The main instruments the government has used have been public procurement policy and direct involvement in R&D. In 1967 a government holding company (Telebras) was created for the national and state telephone service companies. In the mid-1970s the government established a policy for local production and procurement of telecom components and equipment. The goals were to establish a more solid domestic industrial base and to save foreign exchange. This program had two parts. One was to increase the requirements, first, for greater local content in the supply of equipment to the Telebras system and, subsequently, to aim for greater preference toward Brazilian-controlled companies. The second part of the program was to increase R&D in order to prepare Brazilian companies to use new technology and produce new telecom products.

3.40 In 1976 Telebras established the Centro de Pesquisas e Desenvolvimento (CPqD) as its formal research unit and by the end of 1987 the latter had developed 75 different products, many in cooperation with universities and industry. At least 25 of these new products were being manufactured as a result of an active technology transfer program to local industry.

3.41 A 1981 law stated that suppliers to Telebras of electronic switching equipment had to be Brazilian-controlled companies. The law also reserved the digital switching market to the family of digital exchange systems called Tropico, which were being developed by CPqD. As a result, foreign telecom equipment suppliers producing in Brazil (Ericsson, NEC, Siemens) had to restructure to become majority Brazilian-owned joint ventures, and wholly-owned Brazilian companies were strengthened as well. Delays in development of the Tropico program allowed the joint venture companies to bring out their own digital designs for medium (4,000-10,000 lines) and large (over 10,000 lines) exchanges based on foreign digital technology. The market for smaller exchanges (less than 4,000 lines) continued to be reserved for CPqD's Tropico R system. Furthermore, half the market for up to 20,000 lines has been guaranteed for the Tropico RA exchange technology, which was scheduled to be available from CPqD by the end of 1989.

3.42 The Brazilian government, through Telebras' procurement policy, has been successful in developing the local telecommunications industry. By 1987 over 100 firms supplied diverse telephone and telex exchanges, and domestic value-added ranged from 60% to 70% for telephone exchanges to nearly 100% for telephones, VHF radios, and multiplex PCM. However, except for the most standardized products, Brazilian prices are higher than international prices. The gap has widened since the beginning of the 1980s because

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31/ This section draws on Ripper, 1989; and Frischtak, 1989.

32/ Starting in 1973 Telebras began to sponsor applied research projects to ensure that Brazil would be prepared to take advantage of major breakthroughs in telecom technology, including digital pulse code modulation systems, time division multiplexing systems, and stored program controlled exchanges. Most of these research projects were contracted out to university research groups, though some went to private companies.

33/ By 1988 it had 400 professionals in R&D and a budget of about US$60 million.

34/ Frischtak, 1989.
lack of sufficient competition, fragmentation of the market (partly induced by firm-licensing policies), restrictions on foreign technology, and the high cost of most components.35

3.43 Brazil's technological achievements have been impressive, but at what cost and for what benefits? Taking the Tropico program as an example again, Frischtak (1989) estimates that the development of the Tropico R exchanges cost between US$105-$250 per line and that the price of domestic manufactured exchanges is US$400-$550 per line (including a 3% royalty paid to CPqD). That compares very unfavorably with international digital switching equipment prices of US$120-$180 per line. Part of the reason for the high local manufacturing costs is Telebras' practice of certifying individual producers and assuring them a minimum demand, which has reduced the benefits of larger-scale economies. On the benefits side, it may be argued that the Tropico R is a more appropriate product because it is more adapted to Brazilian conditions. It can also be argued that the high development cost is an investment in technological capability development and that future, larger versions are going to be cheaper and faster to develop. On the cost side, however, Frischtak points out that because of a delay in the delivery of the Tropico R technology--after the market had been reserved for it--Telebras continued contracting large volumes of electromechanical exchanges between 1980 and 1985 rather than using foreign digital technology. This meant a higher cost to the Brazilian economy.36

3.44 In computers, the objective has been to develop a strong nationally-owned industry from supermicros down to home computers, peripherals, and sub-assemblies. The government has reserved that segment of the domestic market to Brazilian companies. The policy to develop a national computer industry dates from the mid-1970s when Brazil's military government decided that the country should develop its own computer manufacturing capability. The local industry would thus substitute for computer-related imports, which were one of the main foreign exchange drains on the economy (along with imported oil). However, the government recognized that it would not be feasible to develop a national industry to produce large mainframes and has left that segment to foreign-owned multinationals (IBM and Unisys) already producing in Brazil.

3.45 In 1977, Capre, the government agency for computer imports, selected five Brazilian firms to support in computer production. Two firms based their products on local technology, and three used foreign technology. In 1979 Capre was replaced by the Secretaria Especial da Informatica (SEI), a Special Secretariat for Informatics with links to the National Security Council, to plan the development of the national informatics industry. SEI has been very active in identifying areas for national production, calling for bids by Brazilian companies and awarding production licenses to Brazilian firms including licensing many component product areas. In 1983 the government set up a public research center for informatics, Centro Tecnologico da Informatica (CTI), to develop local informatics technology. However, unlike CPqD, it has not developed strong links with the industrial sector. The government also passed special fiscal incentives for R&D that apply only to firms in the informatics sector.

3.46 By 1985 the value of sales by Brazilian computer companies surpassed sales by domestically-based foreign companies.37 However, prices for Brazilian computers are significantly higher than international prices. Furthermore, it is not likely that Brazilian computers will become internationally price competitive under the current industrial structure. The industry is too fragmented, with many national manufacturers producing at uneconomic scale. In addition, Brazil jumped into computer production without first developing the components; the component industry remains very weak and inefficient.


36/ Frischtak, 1989.

37/ The government has only one 100% state owned company (Cobra) which produces superminis, superminis, minis and pcs, and has less than 10% of the total sales of Brazilian companies.
In consumer electronics the objective has been to use the industry as part of the Amazon regional development program, without concern for local vs. foreign ownership of firms. In return for firms locating in remote Manaus, far from the main markets in southeastern Brazil, and submitting to some local-content requirements, government provides special incentives. These include quotas for imports, elimination of import duties on capital goods and electronics parts, elimination of income tax for ten years, and provision of special financial incentives.

Although the policy was successful in inducing the consumer electronics industry to relocate and expand in Manaus (Philco, Philips, National are there), virtually no link exists between the consumer segment and the rest of the electronics industry in Brazil. In addition, due to the industry's strong inward orientation in response to the protected market, production scales do not match international standards. In color TVs, for example, at least ten producers have fragmented the market. As a result of such fragmentation, Brazilian prices are higher than international prices in most other consumer electronics products, too.

Even though Brazil has a per capita income almost seven times that of China, the share of electronics production in GDP is the same as in China. Even more surprising, the share of its domestic electronics market in GDP is smaller than in China. Since electronics products tend to have a high income elasticity of demand, it is possible that the high price of Brazilian electronics products, as well as the quota restriction on many electronics imports, has slowed the growth of demand. Electronics exports are also low and consist mostly of automobile radios and cassette players made by Philco (Ford) and Volkswagen as part of export commitment agreements. In terms of the structure of the sector, consumer electronics is the largest subsector, followed by electronic data processing. The relatively large share of the latter can also be attributed to the special emphasis that has been given to that subsector in terms of market reserve. Compared to the East Asian NICs, however, the share of Brazil's components subsector is low. Overall, the electronics sector consists of about 2,800 companies employing a little over 250,000 workers.

F. China--The State as Lonely Actor Looking for Foreign Partners

In a centrally-planned economy the state, by definition, plays a critical role in the development of any sector. The Chinese government has given the electronics industry priority because of its importance to defense and industrial modernization. Starting from a small base--the few pre-war plants that existed were severely damaged during World War II--in 1949 the government began to rehabilitate the industry with assistance from the USSR. Since 1949 the electronics industry has grown at about twice the rate of the rest of the industrial sector.

One of the major changes in China in the past decade--its opening to the rest of the world--has had an important impact on policies, structure, and access to foreign technology in electronics. Since 1979 the government's focus has shifted from military electronics to consumer electronics and computers, as well as to the establishment of an integrated circuit industry. It is estimated that military electronics has fallen from a 60%-80% share of the sector ten years ago to about 10% now.

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38/ Developing the Amazon region is linked to strategic military considerations of occupying Brazilian national space in what was a vast underpopulated region.

39/ Because of its very tight market reserve policy, Brazil has a lower ratio of imports to domestic electronics market than China and even India (see Table 3).

40/ This section is based on World Bank, 1989, China Electronics Sector Report, World Bank Report No. 7962, June.
Several government ministries are engaged in electronics R&D, production, and application, the main one being the Ministry of Electronics and Industry (MEI). Until recently, MEI administered electronics activities in most of the factories as well as at the major research institutes, specialized training centers and universities. However, in 1986 MEI turned over most of the daily management of the formerly centrally-controlled factories to local electronics bureaus. MEI now concentrates on strategies for the long-term development of the sector. In 1988 MEI merged with the Ministry of Machine Building to form the Ministry of Machine Building and Electronics (MMEI).

Trade policy has been one of the main instruments for developing the sector. Imports of competing products have been regulated or permitted only under very high tariffs. Effective rates of protection for some of the key products range from 50% to 170%, but noncompeting electronics imports (components and products) pay much lower duties, on average.

Until 1979 China relied mostly on old Soviet technology and its own technology to develop the electronics sector, but the open-door policy in the past decade has attracted DFI into the electronics sector. Direct foreign investment has been channeled into labor-intensive electronics components and consumer products, which are being abandoned by more advanced economies as they move into higher value and more complex products. DFI is also being used to fill gaps in several critical areas of electronics where a new injection of technology is necessary—TV tubes, integrated circuits and, most recently, videotape recorders and compact discs. Having started from zero, by 1986 joint ventures accounted for almost 5% of total electronics output in China.

Although China has also spent over US$2 billion on imports of technology and equipment to modernize its electronics industry, estimates are that its electronics sector is still about ten years behind the international frontier in most areas (except some military electronics applications, formerly the area of its strength in electronics). Because of the fear of being left behind, China has liberalized access to foreign equipment and knowhow substantially. In addition, measures have been taken to encourage firms to carry out more R&D and to make independent R&D centers report directly to enterprises rather than to government ministries.

All segments of electronics in China are characterized by a high fragmentation of production capacity, which means that in most cases they are far below minimum efficient scales of production. The largest producer of personal computers, for example, made only 20,000 units in 1987, compared to scales of over 200,000 units for most international producers maintaining or increasing their market shares. In addition, enterprises lack the capacity for specialization, in part because they diversified into unrelated electronic activities after the demand for military electronics declined. There are problems of coordination of production of plants controlled by different provincial and municipal governments. Thus, supply networks also are poorly developed, and many manufacturers have invested heavily in in-house production of most of their required components and sub-assemblies, at very inefficient scales. As a result of these inefficiencies, poor management, the need to carry large inventories because of the unreliability of supplies, and high tariffs and taxes, the prices of Chinese electronic products tend to be significantly higher than international prices.

To promote greater product specialization and economies of scale and scope in production, marketing, distribution, and R&D, the Chinese government has been encouraging the formation of large group companies. More than 26 groups have been formed, and they already account for over half of electronics production. Intergroup rivalry is expected to provide an important element of domestic competition. It is also hoped that the large vertically-integrated groups will become important exporters. In addition, to promote efficient scale, the government plans to require industrial licensing by MMEI for large projects, to prevent excessive entry and fragmentation in five critical areas of electronics (switching systems, computers, integrated circuits, video tape recorders, color television tubes). Such projects will be screened for technical and managerial capability, and only licensed firms will be permitted to produce.
3.58 The current government strategy is to concentrate on the low and medium end of consumer electronics as the major engine of growth for the electronics industry. This strategy is expected to help the rest of the electronics sector by providing expertise in high-volume manufacturing and assembly; experience with product design, development, engineering, and assembly; and knowhow on sourcing components and parts--through developing an effective network of suppliers of electronic materials, components, and manufacturing and testing equipment. The consumer electronics segment, especially color TVs, also is expected to be China's major base for promoting exports of electronics products. Color TV technology is relatively mature, China has a sufficiently large domestic market for economies of scale, and its low labor costs provide some advantage. However, the infrastructure for active components, printed circuit boards, and electronics-grade production equipment and materials is weak, and prices are high. Moreover, the capital goods industry has been slow to respond. China would do well to learn from the experience of Korea and Taiwan that it is important to develop the supporting industries as part of an effective product sequencing strategy.

3.59 In spite of being the largest of the developing economies in population and in apparent consumption of electronics, China's electronics production is considerably smaller than that of the four East Asian NICs. These latter have followed export-oriented strategies because of their smaller size. China has the lowest export-to-production ratio of the countries reviewed.

G. India--The State as Main Actor and Regulator

3.60 India's electronics industry, established by the state in the 1960s, has developed in a heavily protected environment in which the state has been the main actor and regulator. Public sector enterprises still account for about 40% of the electronics sector's output. Indian Telephone Industries (ITI) and Hindustan Cables Limited (HCL) dominate telecommunications; it has only been since 1984 that private firms have been allowed to produce. Several large public sector enterprises also dominate the industrial electronics subsector. Two public sector enterprises dominate components as well, producing all small and medium ICs. Large-scale ICs still are imported. The rest of the electronics sector is fragmented since an explicit government policy reserves part of the sector for small-scale producers. More than 24 product areas, some of which require scales for efficiency, were reserved for small industry until recently.

3.61 Industrial licensing requirements by the government have severely regulated entry and exit for firms and restrained the growth of the most efficient producers. Larger firms were prevented from expanding because they were dominant or foreign owned. By encouraging geographic dispersion of the industry among the country's many states, the government prevented the geographic concentration necessary for developing a strong supportive infrastructure.

3.62 The Indian electronics sector is domestically oriented, with less than 7% of production exported. It imports about half the required materials and components. High tariffs and bans on competing imports have led to very high levels of effective protection, which has prevented competitive pressure and discouraged exports. The sector consists of about 2,600 firms employing over 70,000 workers.

3.63 Because of the Indian government's stringent policy of technological self-sufficiency, strong restrictions on DFI and on technology transfer have been the norm. Such constraints, combined with a heavy public enterprise presence as well as the policy of reserving a large part of the components subsector

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42/ The Indian government unsuccessfully tried to force IBM to sell a majority share of its Indian operation in 1960. However, IBM decided to close up shop and leave rather than to divest majority ownership. Restriction on royalty payments and other limitations have also turned away more sophisticated technology in many areas.
small-scale enterprises, have resulted in an inefficient sector with high costs. In some product lines, production scales are substantially smaller than minimum efficient scales by 20 to 100 times. Process technologies are generally eight to ten years behind, and product technologies generally five to six years behind. Indirect taxes and high customs duties on imports amount to 20% to 30% of sales prices. In 1986, for ten major products, Indian factory prices were 20% to 170% higher than world prices, and many products were of inferior quality. One of the few areas where Indian firms could be competitive by world standards, if they could get inputs at world prices, is consumer electronics based on relatively simple and mature technologies. Another area for potential international competitiveness includes products that require skilled labor or computer software, both of which are low cost in India.

3.64 In the 1980s the government targeted electronics as a source of productivity improvement for the industrial and service sectors. As a result, and especially since 1985, electronics has been singled out for a series of liberalizing policy reforms: gradual liberalization of the restrictions on entry and exit; more flexibility to adjust both output mix and capacity in those sectors still subject to licensing; virtual elimination of the policy of reserving some products for small-scale industry; and access to imported capital goods assured through an open general license category.

3.65 Telecommunications, formerly the exclusive preserve of the public sector, was opened in 1984 to the private and joint sector for the manufacture of telephone handsets and PABXs; this broadened in 1988 to include rural exchange and transmission equipment (for majority state-owned firms). Improved access to foreign technology and relaxation of restrictions on firms with more than 40% foreign ownership have taken place, parallel with domestic deregulation. Finally, quantitative restrictions have been greatly reduced for components, and the import duty structure has been rationalized, with raw materials generally at 35%, processed parts at 50%, components and peripherals at 80%, and final products from 90% to 150%.

3.66 Though belated, these policy changes are having some positive effects on the competitiveness of Indian electronics. Since 1985, ex-factory prices have fallen as much as 60% for some products, such as color TVs and microcomputers. Exports of electronics products (excluding those produced in duty-free zones), which were stagnant in 1984, have more than tripled since then, growing from 2.7% of production to 3.9% by 1987. However, the policy changes have not gone far enough. India still has a long way to go to become internationally competitive across a wide spectrum of electronics products.

3.67 Partly as a result of its policies, India has the smallest electronics production among the countries reviewed. It also has the smallest ratio of electronics production to GDP and very low import and export ratios. In terms of structure of the sector, it ties Hong Kong in having the highest share of production in the consumer electronics subsector. However, it has the lowest ratio in electronic data processing and in components. On the other hand, it has a very broadly diversified sector with the highest shares in control instrumentation and communications and military use among the developing economies reviewed. This is reflective of the strategy of going for great breadth and little sequencing. It also reflects the strong role of the military in the sector.

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43/ A World Bank study of the Indian electronics industry completed in June 1987 suggested the following additional policy changes: progressively eliminating quantitative restrictions on imports and further reducing tariffs; simplifying and eventually eliminating the Phased Manufacturing Program which encourages uneconomic levels of local content; eliminating remaining restriction on technology imports; extending capacity delicensing to industrial electronics, computers, and telecommunications; removing remaining dominant firm clearance requirements for product where scale is needed for efficiency; and easing restrictions on exit of inefficient firms.

44/ It is quite competitive in some segments of software, however, due to the low cost of Indian engineers.
H. Korea—The State as Creator of Private Conglomerates to Battle Abroad

3.68 A large part of Korea's success in developing its electronics sector can be attributed to its four largest conglomerates—Samsung, Goldstar, Daewoo, and Hyundai. The government fostered the development of these conglomerates as a way to reduce its transactions costs in dealing with the private sector and with the desire to create large firms capable of defending themselves in foreign markets. These four have done well in the fast-moving electronics industry because their deep financial pockets, cross-subsidization activities, internal technical labor markets, and economies of scale allow them to compensate for market failures characteristic of high technology products. Such market failures include requirements for lumpy capital investments, difficult access to product and process technology, as well as general uncertainty.

3.69 Samsung and Goldstar entered the electronics market in the 1950s, producing consumer electronics and progressing from radios to black and white and then color TVs based on imported technology. Eventually they entered the computer and semiconductor markets, and Daewoo followed later; all three compete across a wide range of electronics products. Hyundai was a latecomer and did not pass through the consumer electronics stage but entered the computer and semiconductor fields directly in the mid-1980s. All four firms have integrated facilities for production of up to 1 M DRAMs. Samsung and Goldstar also already have facilities for the production of 4M DRAMs.

3.70 The Korean government's main resource for strengthening the large conglomerates was subsidized credit directed to such firms through the national banking system. It should be clarified, however, that the government did not promote these conglomerates exclusively for exports and for the development of the electronics industry. It promoted them mainly for the development of heavy industry. These conglomerates branched out into many subsectors, eventually spawning the electronics industry.

3.71 Although consumer electronics started as local assembly operations by Japanese and U.S. subsidiaries, the Korean government placed tariffs and quantitative restrictions on imports of consumer electronics products and computers, and restricted foreign investment, all to promote production by national companies. The only unprotected sector was semiconductors, which the conglomerates undertook to develop on their own, not at the government's urging.

3.72 Government procurement was important in the development of the computer and telecommunications subsectors in Korea. The government also set up a large public research and technical training infrastructure to foster development of researchers: the Korea Advanced Institute of Science and Technology for advanced technical degrees and research, as well as two more specialized research institutes dedicated to the electronics sector. The first was the Korea Institute of Electronics and Technology (KIET). The other research center was the Korea Electronics and Telecommunications Research Institute (KETRI, now called ETRI).

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45/ In 1987 the first three had sales of 21, 14, and 13 billion U.S. dollars, respectively and were among the 35 largest non-American industrial corporations in the world as reported by Fortune magazine, August 1988. (No data was available on Hyundai because it is printing held.)


47/ See Mody, 1989(a) for a fuller development of this argument.


49/ Mody, 1989b.
KIET was set up in 1979 to help bring industry to the state-of-the-art in semiconductor technology and to stimulate cooperative research in the private sector. However, once the private sector realized the possibility of producing semiconductors locally, it moved forward with its own production lines based on technology licensing and foreign expertise. In 1985 KIET's facilities were sold to one of the large Korean conglomerates because they were becoming obsolete as research facilities. Although KIET did not fulfill its objective of fostering cooperative research among private firms, it played a catalytic role in demonstrating that it was possible to produce semiconductors in Korea. It also trained researchers and engineers who then migrated to the private sector.

KETRI originally focused on telecommunications but subsequently absorbed the functions of KIET. It has been important in developing advanced telecommunications protocols and transmission devices. KETRI also coordinated joint research on the development of the 1 M DRAM and 4 M DRAM by Korean firms. However, the big conglomerates have their own advanced electronics research facilities, and government research centers have had to switch their role to more generic pre-competitive research.

In Korea about 1,200 firms employ more than 350,000 workers in the manufacture of electronics products. More than half the firms produce parts and components. Almost 85% are locally funded. The rest have some foreign capital. The main foreign firms are IBM, Motorola, National Semiconductors, Philips and Fujitsu.

Korea's electronics production was lower than Taiwan's through the early 1980s, but it grew more rapidly and by 1987 had overtaken Taiwan's. In addition, Korean industry has moved into higher-value electronics products, such as VCRs and more complex computers and components than produced in Taiwan. Mody (1989a) attributes this to the advantages of scale and scope of the large Korean conglomerates. Therefore, an important part of the success in electronics seems to be based on the government's early decision to foster the development of large conglomerates to battle in international markets. The largest segment is components, whose 41% share is the highest for any of the countries in the sample (Table 4). The second highest share is consumer electronics. This reflects the sequencing strategy of starting from mere assembly of consumer electronics products and then deepening by producing the components. Korea is still heavily dependent on imported parts and components, however, mostly from Japan.

Taiwan--The State as Incubator and Supporter

Taiwan's electronics industry started in the 1960s, when the government changed its industrial policies from an import-substituting orientation to export promotion--basically export-oriented assembly for foreign companies. The government set up various incentives for export-oriented industry, including export processing zones (EPZs). Taiwan's low-cost labor and the export facilities attracted many foreign electronics firms. The export industry grew quickly, with much spillover to the local economy in terms of direct and indirect diffusion of foreign production technologies, management and marketing techniques, subcontracting with local firms, and training.

The industry that developed was based primarily on consumer electronics, starting with radios and progressing through black-and-white TVs in the 1950s and 1960s to color TVs in the 1970s, and finally monitors and minicomputers in the 1980s. It was also very strong in watches, toys, and telephones based on imported ICs.

Korea is the second largest producer of VCRs and microwave ovens in the world (after Japan) and the third largest producer of dynamic random access memories (DRAMs).

The two largest local electronics firms, Tatung and Shampo, formed joint ventures with Japanese partners. The larger is Tatung, with 1984 sales of US$500 million (compared to Korea's Samsung with US$10 billion in the same year, of which US$2 billion was in electronics). Tatung dominates the production of monitors. It is an original equipment manufacture (OEM) supplier for the IBM PC and has had a long relationship with IBM.
3.79 In the mid-1970s, however, the government began to emphasize further development of the electronics industry due to its increasing importance in the domestic economy and with the objective of achieving international competitiveness. At the end of 1981, electronics and machinery were given priority status as strategic industries. The Ministry of Economic Affairs (MOEA) initially selected 151 strategic products, of which 64 were electronics related. By 1987 there were 199 strategic products, of which 91 were electronics-related. Incentives for manufacturing strategic products included low-interest finance, assistance in technical and operational management, exemption or reduction of tariffs on machinery imports, and income tax reductions.

3.80 More generally the government also has provided a nurturing and supportive environment through the establishment of the Hsinchu Science Based Industrial Park, to encourage foreign high-technology companies to locate in Taiwan and to nurture the development of local companies. The industrial park was established in 1980 and by 1987 had over 70 firms, mostly in electronics. The park provides a supportive environment, which besides the basic physical and administrative infrastructure, includes special tax incentives, low financing (even equity participation), manpower and management training, and great technology support infrastructure. The latter includes the Industrial Technology Research Institute (see below) as well as two of the top technical universities in Taiwan.

3.81 Different strategies have been used to develop different parts of the industry. One of the clearest contrasts is the strategy for the videocassette recorder (VCR) industry and semiconductors industry.

3.82 For example, strong import controls were used to develop local production of VCRs. In 1982, 1,533 items from Japan were banned as part of Taiwan's plan to reverse its large trade imbalance with Japan. One of these products was videocassette recorders. Since Japan was virtually the sole world producer at that point, the ban on Japanese imports amounted to a virtual total import ban. However, this ban benefited a local company that had started research and development to produce VCRs domestically and had previously entered into technology licensing agreements with Toshiba and JVC of Japan for local production; the company was able to start up production within a few months of the ban's imposition. Other local companies began production over the next five years, one under a licensing agreement with Sharp and one as a joint venture with a Japanese company.

3.83 However, the orientation of VCR production continues to be toward the domestic market. Firms lack the economies of scale to be efficient low-cost producers. In addition, about 60% of the VCR components are imported, and although import duties on VCRs were reduced to 35% by 1986, those on components remained at 50%. Thus, in 1986 local VCR prices were still above world prices. Korean VCRs

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52/ MOEA identified the scope of strategic industries under the criteria of "two highs (high value added and high technology intensity), two bigs (big linkage effect and big market potential), and two lows (low pollution, and low energy intensity)" [Lin, 1987]


55/ Unlike Korea, the government has been much more open to foreign firms. This policy, not applicable to the electronics sector alone, seems related to a certain distrust for big business, perhaps carried over from the days of Sun Yat Sen.

56/ Two of the companies set up in park, Acer and Mitac had 1988 sales of 380 and 293 million dollars respectively. They were two of the only three developing country companies among the top 50 non-US information services companies in the world, in the yearly list compiled by Datamation.
were making inroads in the domestic Taiwanese market, and Taiwanese exports were small in comparison to Korean VCR exports.5

3.84 In contrast to VCRs, the semiconductor and computer industries have been promoted mostly by developing a strong technological base while keeping an open import policy. One of the main instruments has been the Electronics Support Service Organization (ERSO), established in 1974 as a specialized research center within the Industrial Technology Research Institute (ITRI), Taiwan's premier public research institution for industry. ERSO's major function is to help the government carry out research in electronics for both the public and the private sector. When ERSO began, Taiwan's electronics industry relied completely on imported integrated chips.6

3.85 The first major responsibility of ERSO was to acquire and develop the IC technology for production in Taiwan and to transfer it to the private sector, as part of the government's Electronics Industry Research and Development Plan. To do that, ERSO first studied and visited 30 leading semiconductor manufacturers in the U.S. It then licensed technology from RCA and with assistance of RCA engineers set up a production facility within the research center. Once the research center was successful in designing and manufacturing ICs, the government used the new expertise to help establish the United Microelectronics Company (UMC), a joint venture with the private sector and the first firm successfully to produce ICs locally. ERSO participated very heavily in the design and technology transfer to the UMC, including the transfer of many engineers from ERSO.7

3.86 ERSO also has been influential in further development of the electronics industry in Taiwan. As part of the government's Very Large-Scale Integration Plan (1983-1988), ERSO established the Center for Common Design Service to diffuse IC design technology to industries and to help them design the specific-function ICs. Many IC design companies in Taiwan have been set up by former ERSO circuit design managers and staff. ERSO also helped set up (1987) the Taiwan Semiconductor Manufacturing Company (TSMC), a joint venture among ERSO, local private industrialists, and Philips of Holland.8 TSMC is a silicon foundry that produces IC masks from design specifications provided by local and foreign clients. In addition, ERSO has

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57/ Based on Lin, 1987.

58/ The telecommunications equipment industry (other than telephones) is also not particularly competitive. The main reason appears to be that it has been overregulated for national security reasons. Much civilian telecommunications equipment is not allowed to be produced or marketed. As a result, that subsector has the largest technological gap among the electronics industries with respect to the international frontier. See San, 1989.

59/ Taiwan's semiconductor industry started in 1966 with the establishment of a plant by General Instruments (a U.S. company to assemble transistors). By the end of the decade, several other foreign companies, including Texas Instruments and Philips set up semi-conductor assembly plants based on imported components.

60/ Lin, 1988

61/ Philips started with a 25% equity stake in TSMC. Besides transferring its 2 micron technology Philips guaranteed that until domestic demand was large enough, it would feed the output through its own international supply network. This allowed TSMC to produce at the high volumes required for economic efficiency from the very beginning. Philips may also increase its equity stake to 51% and move a large scale manufacturing project with Siemens to Taiwan.
helped local firms import, assimilate, improve and develop technology and products, set up or expand plants, and has trained many engineers and researchers working in the private sector. 62

3.87 On the software side, to promote the development and use of computer technology, the government in 1979 established the Institute for the Information Industry (III). Its objectives include introducing and developing software technology, assisting government agencies and public enterprises in computerization, and training and educating professionals in the information area. It has developed a comprehensive ten-year program to achieve this.

3.88 In the education area the government has stressed the engineering fields, especially electronics engineering. According to the III, by July 1987 there were 114,628 graduates from the electronics and information science fields and another 57,942 studying in the same fields in colleges and universities. In addition, the government established two special programs to help provide in-service training in this area. The first is through public training institutes for entry-level and middle-level manpower. The second is a five-year promotional plan for the information industry to train at least a thousand government employees annually in computer-related courses. Furthermore, the government has established a comprehensive certification program for workers in the informatics area. It tests workers' ability and certifies them at different levels, which provides the flexibility needed to complement the rather rigid formal educational system. 62

3.89 Electronics in Taiwan consists of more than 3,300 firms employing at least 300,000 workers. Overall, Taiwan has the second largest electronics sector among developing economies, having recently been surpassed by Korea. Moreover, Taiwan's production is both more import intensive and more export oriented than the Korean electronics sector (see Table 3). In terms of the structure of the sector, components account for the highest share, followed by electronic data processing and consumer electronics. The unit value of Taiwan's exports in consumer electronics, however, tends to be lower than that of Korea's exports. 62 Taiwanese companies tend to specialize in niche markets, which capitalize on their ability to absorb foreign technology, and to invest and produce quickly for fast returns.

J. Singapore--The State as Landlord for Foreign Capital

3.90 Singapore's development strategy has been to attract foreign firms by providing a disciplined and well trained labor force as well as an excellent physical and communications infrastructure. Singapore has the second largest port in the world in tonnage moved, the third largest airport in terms of flights, and one of the most advanced telecommunications systems in the world. The development of electronics has been based almost exclusively on foreign firms working in Singapore. Very open to direct foreign investment, the state, through the Economic Development Board, tries to persuade suitable foreign companies to set up production facilities in Singapore.

3.91 Furthermore, the Singaporean government had a very definite role in pushing for an increase in local value-added in increasing the skill level of the local population. This was done by imposing a tax on lower-skill activities, coupled with many programs to increase the skill levels of workers through on-the-job training. There has also been a significant increase in formal education oriented to the higher technical and engineering areas, especially electronics. Forty percent of all students enrolled in higher education are in engineering. In addition, the government has pioneered some very innovative programs with foreign governments and foreign companies to train workers in critical electronics-related areas. Foreign companies such as NEC and IBM enjoy special incentives and even special grants to train more people than they need in critical areas.

62/ One of the first eight bit computers produced by ACER was designed with help from ERSO.

63/ San, 1989.

64/ Mody, 1989.
3.92 Although the government has not used trade policy to develop the local electronics industry, it has set up several key public enterprises in the electronics/informatics area. These have close links with the defense establishment and with software development in more traditional government areas such as managing the airport and port traffic and the newly built rapid transit subway system.

3.93 Although Singapore is the smallest of the developing economies studied, it has the largest electronics exports. Also, it has the highest ratio of electronics production to GDP of all the economies reviewed in this paper. Its production structure is unique in that it has the highest share of electronic data processing, due to the production of such equipment by the foreign multinationals located in Singapore. The second largest subsector is components, with consumer electronics a distant third.

3.94 Consistent with its general strategy of laissez-faire, the government of Hong Kong has not had a direct role in the development of its electronics industry. Electronics started up in the late 1950s and early 1960s with transistor radio assembly plants. These were well suited to Hong Kong, requiring little technical knowhow, cheap labor, and relatively little capital. Radio assembly grew quickly. In 1962 it expanded into electronic components for radios because Japan imposed an embargo on the export of its components to Hong Kong, due to Hong Kong's success. The ban was soon lifted as Japanese suppliers realized that Hong Kong could manage without Japanese supplies. By 1968 the component sector accounted for 52% of electronics output. In addition, in the late 1960s production diversified into television and computer components and assembly of television sets. By 1970 electronics accounted for 10% of total domestic exports and 9% of manufacturing output. Over 70% of the electronics exports went to the U.S.—with many U.S. firms using Hong Kong as a cheap offshore production site for sales to the U.S. market. Hong Kong's electronics industry also got a boost from Japan, the world's largest supplier, when the latter shifted to higher-priced radios and faced restricting its sales to the U.S.

3.95 In the 1970s and early 1980s, Hong Kong's electronics industry diversified further into many consumer products and components, including high-fidelity components for sound systems, cassette recorders, electronic watches and clocks, electronic toys and games, wired and cordless telephones. More recently it has also diversified into computers and computer peripherals (modems, disk drives, floppy disks, printers, computer memories and add-on cards), PABX, cellular phones, fax machines, and computer-aided design and testing equipment. It also produces multilayer printed circuit boards, liquid crystal displays, quartz crystals, and semiconductor devices, including integrated circuit wafers. In addition, it also has a number of software houses serving its sophisticated market.

3.96 In 1988, the electronics industry was the country's second largest exporter after the clothing industry, and consisted of almost 2,000 firms employing almost 110,000 workers. The majority of firms are small, locally owned component producers or assembly plants, but there is still a heavy foreign presence of large multinationals, including Digital, Motorola, National, NEC, Sanyo and Philips.

3.97 The structure of production is very heavily weighted to consumer electronics, particularly the lower end—radios, toys, watches, and simpler televisions and computers (Table 4). Among the eleven economies being reviewed, Hong Kong also has the highest share of production in office equipment, mostly calculators (Table 3). Hong Kong also is both the most import dependent and export oriented. Imports are 142% of electronics production, while exports are 174% of production. The electronics industry in Hong Kong is therefore mostly an assembly industry based on imported components that are used in low-end electronics exports.

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Until recently, the technology to assemble and manufacture fast changing consumer products was considered relatively unsophisticated. Companies spent only a very small share of sales on R&D and aimed for short-term returns based on quick production for niche markets. More sophisticated products are produced mainly by assembling advanced components imported from Japan. However, because of the threat of the rapid growth of application-specific components, Hong Kong has seen the need to break away from assembly-intensive work into design and manufacture of more specialized products. Thus, recently the government has become more interested in assisting the industry and has started to focus on improved education and training of electronics engineers and promotion of direct foreign investment to obtain the more advanced technology needed to remain competitive.
IV. CONCLUSIONS AND POLICY IMPLICATIONS

4.01 Clearly, the questions raised at the beginning of this review cannot be answered entirely satisfactorily, even with more data than are currently available. What follows presents some preliminary judgments on the relative success of different strategies and the probable reasons for those successes. First a distinction needs to be made between leader and follower strategies. A leader strategy is based on being the technological innovator and requires a very strong scientific and technological base. A follower strategy is based on being very fast at bringing the new products to market. Unless impeded by very high barriers to entry, being a follower is easier because there are clear guideposts. Until recently the U.S. has been the clear leader in electronics technology. The European countries, Japan, and the developing countries have been followers. Governments have had scope to identify gaps or problem areas and to plan how to approach such problems. The material below focuses on the followers, particularly the less developed economies, although reference will necessarily be made to Japan because of its relatively recent transition from developing to developed country and its clear success in electronics.

4.02 The most successful performers in developing internationally competitive industries have been Japan, Korea, and Taiwan. Although they have tended to rely on the private sector, the state has played an important role as well, as coach, father, nurturer, respectively. Possibly the complexity of the strategies required to be successful in such a dynamic sector makes it necessary to rely on agile private sector players.

4.03 Hong Kong also has been successful, although limited primarily to simple consumer electronics goods and computers. The prospects of its moving rapidly up to more complex products are not likely because of its shallow technological base for electronics. This shallowness relates partly to lack of investment in technological infrastructure, which in turn is related to the laissez-faire attitude of its government. Yet Hong Kong's strategy has some merits, as attested to by the rapid growth of electronics output and the increase in quality. Hong Kong's electronics sector thrives on flexible adaptation to new market niches in the simple products area, based in large part on its excellent integration into international supply and export networks.

4.04 Singapore, too, has succeeded in building a large rapidly growing export oriented electronics industry. Singapore's strategy is highly reliant on foreign capital and knowhow, which implies lack of local control. But as in the case of Hong Kong, the issue of foreign control is just another wrinkle in these city-states' extreme dependence on international markets for their very survival. Furthermore, the rapid growth and expansion of the electronics sector has led to much employment and an increase in living standards in Singapore.

4.05 The least successful, in terms of international competitiveness, have been India and China. They are the poorest in per capita income although not in the absolute size of their technical human resources. Part of the reason for their relatively poor performance in electronics appears to have been their excessively autarkic approach until most recently and the very heavy state presence and control of the electronics sectors.

4.06 Brazil's experience lies between that of China and India, on the one hand, and the East Asian NIEs, on the other, through probably closer to the former. Brazil set out to develop a nationally owned and controlled computer industry and clearly has been successful. A more difficult issue is to what extent the national industry is internationally competitive. In the minicomputer area it is behind the East Asian NIEs because of its policy of market reserve -- which has supported the development of a thriving yet internationally uncompetitive industry. In some other areas, such as automated banking terminals and telecommunications, Brazil is ahead of the East Asian city-states and, in a few products, perhaps even ahead of Korea and Taiwan. In most areas of consumer electronics it is clearly behind Korea and Taiwan—
though it sought to develop that sector with very strong participation of foreign subsidiaries. The main problem is that the government forced the consumer electronics industry to locate in the middle of the Amazon, for regional development objectives, and thereby imposed very large transport and infrastructure costs on the industry.

A. Elements of Successful Strategies

4.07 Before attempting to draw out some lessons, it is instructive to contrast the strategies followed by the large semi-continental economies—Brazil, China and India—with those followed by Korea and Taiwan, on the one hand, and those followed by the city-states of Singapore and Hong Kong, on the other. Perhaps because of their larger internal markets, the semi-continental economies have been much more domestically oriented. Yet except for Hong Kong, production in the much smaller Asian NIEs is considerably greater than in the semi-continental economies (see Table 3), and the Asian NIEs' products are almost uniformly more competitive. The reason is clearly their strategy of focusing on export markets to overcome the limitations of their small domestic markets. The export thrust also has placed the smaller East Asian NIEs in direct contact with rapid changes in global technologies and markets, thus providing incentives and knowhow to respond competitively. Lest it be thought that an export orientation, as opposed to a domestic orientation, is dictated just by smaller market size, it should be noted that Japan, which has a much larger internal market than the semi-continental economies, also adopted a strong and successful export orientation.

4.08 Also, the semi-continental economies generally have a more targeted approach and have given a much greater direct role to government than have the four Asian NIEs (see Tables 1 and 2). An important factor has been that in their targeting, the semi-continental economies have focused too broadly and have hurried to develop the whole electronics industry based on import substitution. The Asian NIEs instead have focused more narrowly and have progressed sequentially—from production of components and assembly for foreign consumer electronics, to production of components and simple consumer electronics by their own national firms, and then to production of computers and more sophisticated electronics products and components, as their experience grew.

4.09 Finally, regarding government's role and the strategies in Korea and Taiwan compared to those elements in the two Asian city-states of Singapore and Hong Kong, the main differences have been: the smaller role of government in the latter two in providing trade protection, or in using government procurement, or in activating an industrial organization strategy; and especially the more open attitude toward direct foreign investment. Although the electronics industry in both Hong Kong and Singapore thus has developed in a much less planned way than in Korea and Taiwan and is more narrowly focused, that development has followed a sequence determined more by foreign firms making use of the comparative advantage of producing there than by government. However, as noted, government has had a greater role in Singapore than in Hong Kong, and many would attribute Singapore's better performance to that more active role of the state in promoting the move toward higher technology industry.

Lessons Learned

4.10 Some of the lessons that may be inferred from the experiences reviewed in this paper include the following:

4.11 First, the key aspect of a successful industrial strategy, in this case for electronics, appears to be a combination of protection and nurturing during the initial phase of development; but at the same time demanding improved performance. The latter has been achieved primarily by forcing firms to compete

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This characterization of Brazil, China, and India as the semicontinental economies is taken from Ernst and O'Connor (1989).
abroad but also by encouraging strong domestic competition. That has been the essence of success for Japan and the East Asian NIEs. Conversely, extended protection without demanding improved performance has been the main reason for the uncompetitiveness of the industry in Brazil, China and India.

4.12 The second lesson is that a focus on export markets is important not only for competitive pressure but to achieve economies of scale. High fixed costs of research need to be amortized over as large a production base as possible. The larger cumulative production made possible by export markets leads to dynamic learning since more experience is required in production. A strong emphasis on exports opens up a "window" on new technology and market trends, which is crucial in a sector as dynamic as electronics.

4.13 This leads to the third lesson, which is the importance of continuous access to foreign technology. Because technology is changing so quickly in electronics, and because no country, not even the U.S., is fully autonomous in technology, it is essential for firms to be aware of and to draw on the advances being made by others. Furthermore, because foreigners often are not willing to license their technology, it may be necessary to open up the domestic industry to foreign investment in order to have access to that technology—not necessarily the total openness of Hong Kong and Singapore, however. The success of Japan and Korea has to some degree been related to the strategy of developing strong domestic firms.

4.14 The fourth lesson involves selectivity. It is possible to target the electronics sector too broadly, part of the problem with the approaches of India, Brazil and China. If a country is to target a sector, it is important to be selective in targeting and to expand only as capability builds up. The hard part of this however is deciding what to target. Even some developed countries have not been too successful in targeted efforts. For example, in spite of diverse government efforts in France to create a national champion to compete with IBM in computers, that strategy was not successful.

4.15 A fifth lesson highlights the importance of the general economic environment and the flexibility of capital and labor markets, particularly for dynamic sectors such as electronics. Enough risk is inherent in the speed of technical change and increased international competition; unstable macro policies and poor growth prospects impose an unreasonably high burden on planning and competing effectively. A healthy macroeconomic environment and prospects for growth also appear to be important in order to stimulate research and investments in modern plants and facilities. This seems to have been particularly important in the cases of the U.S. and Japan as well as in the rapidly growing East Asian NIEs.

4.16 A sixth lesson is that the role of government changes as an economy matures. There are market failures, and some countries have developed institutions to help bridge those market failures: the conglomerates in Korea, government coordination and guidance in Japan, and the nurturing research infrastructure in Taiwan. However, as can be seen very clearly in the experiences of Japan and Korea, government's role eventually diminishes: active at the beginning of an industry's development, but reducing its influence as firms and institutions mature. The electronics industry came to rely mostly on the private sector as it developed its own capability without government intervention.

4.17 A seventh lesson is that the electronics industry should not be viewed as an end, but as a means to increased efficiency and competitiveness. Seen as an end in itself, electronics development tends to lead to creation of inefficient capacity, as in the computers subsector in India and Brazil. This also opens up the issue of production versus use. As Flamm (1989) has emphasized, the main returns in computers come from their use, in the economy as a whole, not their production.

4.18 An eighth lesson is that governments have not succeeded alone. Success has depended on many circumstances, including the level and quality of technical human resources, the quality of the supporting technological infrastructure, and the dynamism and quality of management and entrepreneurship in the private sector. More general conditions, such as the quality of macroeconomic management and the
flexibility of capital and labor markets to adjust to changing conditions, also affect the prospects for success. However, it is difficult to disentangle cause and effect in assessing to what extent government intervention has led to success.

4.19 Finally, it must be kept in mind that the role of the government will depend not only on its own capabilities but also on the level of skills and capabilities in the productive sector and on the opportunities in the international environment. What may have been feasible for one country at a particular time may not be readily replicable by another at a later time. Thus, for example, the strategy of entering the electronics industry through simple assembly for export based on low-cost labor, as was initially done by the East Asian NIEs, may not be viable now. First, the industry is much more developed and already relies on established suppliers for the simpler components. Second, low-cost labor is not that much of an advantage anymore because rapid technical change involving increased automation has reduced the importance of labor as a share of total cost. Third, to be an effective competitor in the world market goes beyond low production costs to high quality and rapid delivery times. Both require more quality consciousness and institutional and support infrastructure (such as efficient customs, transportation, and communications services) than most new entrants may have.

B. Four Key Roles of the State

4.20 The above summary, having raised again the issue of the state's role in the development of the electronics sector, points to four roles on which there is likely to be general agreement:

1. **To develop appropriate technical human capital.** Technically trained people who can follow and assess the rapidly changing technologies of the electronics industry are essential in developing a country's capability to participate effectively in the growth of this sector. This raises the question of what types and levels or technical human resources should be trained and how. Unfortunately, there still are no clear answers to this question, and further research is warranted on this topic.

2. **To strengthen the basic technological infrastructure**

   - One key element of technological infrastructure is ensuring access to information and technology and disseminating it locally. This can take many forms, ranging from bargaining (as was done extensively by national firms in the early phase of the development of the Japanese electronics industry), to providing specialized institutions to help collect, monitor, assess, and diffuse technology.

   - A second important element of technological infrastructure is basic metrology, standards, certification, and testing facilities, which help to ensure quality control and diffusion of technological knowledge. Here the government has an important role in establishing the institutional structure to set necessary measurement standards and certification procedures, and in helping to finance the establishment of some of the basic measurement and advanced testing facilities; equipment often is too expensive for individual firms to invest in.

   - A third element is providing some degree of research infrastructure to help local industry assess the relevance of technological advances and help local firms acquire technology. In Korea, public R&D institutes have helped firms bargain for access to foreign technology (for video cassette recorders and microwave ovens). In Taiwan the public R&D institute was instrumental in setting up semiconductor fabrication capability in the country. As the local industries' capabilities mature, research may evolve to develop special new applications of

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67/ Similar key roles for the state have been identified by Ernst and O'Connor (1989).
technology or even to develop new technology. However, the important point is that at all times the focus of the research institutes needs to be on serving the needs of the productive sector rather than on trying to develop technology for its own sake.

(3) **To provide the right incentive regime to stimulate firms to improve their technological levels.** In the early phase this may involve some nurturing so that firms are able to acquire technology. But nurturing has to be combined with performance requirements, especially for exports. Japan and Korea perhaps have been the best at combining these two. In the area of R&D this is also linked to the issue of intellectual property rights. There has to be some guarantee that firms that develop new technology will be able to maintain ownership of that technology so that there will be sufficient incentives for investment in R&D. In addition, adequate intellectual property right protection may be necessary to induce some foreign investors to transfer advanced technology.

(4) **To provide an environment for flexible adjustment to production structure.** This was found to be one of the most important elements for successful adjustment in a recent comparative study of economic performance among OECD countries. Although this holds as a general proposition, it is particularly important for a sector as dynamic as electronics. Precisely because of that dynamism, there is a premium on flexibility and rapid responses to changing technology and competition. Government has an important role in helping to develop some of the necessary institutions, including training and capital market institutions, besides the basic technological infrastructure already mentioned above.

C. Some Remaining Issues

4.21 There are some issues on which there is less consensus, however, the principal one being the desirability or appropriateness of targeting. Targeting can be of two types: defensive targeting based primarily on protecting the sector through such instruments as trade barriers (tariffs, quotas, "voluntary" export restraints), government procurement preferences, "buy national" policies, etc.; and positive targeting based on supporting the industry through R&D, investment, and special training incentives. It should be noted that in both the U.S. and Hong Kong, which are the two countries that have followed the least interventionist approach to the development of their electronics sectors, pressures are increasing for more targeting and government support. Whether targeting is chosen by the U.S., and how broad its coverage might be, will have implications for developing countries.

4.22 However, regardless of whether the U.S. begins any type of targeting in electronics, it is significant that there is now such an active debate on the merits of targeting. Such interest has been a reaction to the perceived success of the more targeted approaches of other countries, most notably Japan, and indicates a growing belief that the electronics sector is strategic and that there is an important role for government in its development.

4.23 One of the critical issues here is how best to identify which sectors to target. Particularly in the U.S., judging the importance of some of the new technological areas is difficult. It is thus risky to make targeting choices because of the uncertainty inherent in new areas. Nevertheless, it is again important to distinguish leader from follower strategies. In the U.S. the debate is really more in terms of supporting national industry in the development of new technologies, not in terms of follower strategies. But the issue for developing countries is much more in terms of targeting according to follower strategies. As indicated previously in this review, follower strategies are easier, provided that the underlying technologies do not change radically. The key is to select the right niches and sequencing to build cumulatively from the easier to the more complicated. It should also be noted that the degree of government involvement in directing

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or targeting a sector should not be independent of the administrative capability of the government and the quality of its civil service. Also, it should be remembered that targeting has both direct and indirect costs. The direct costs are the special incentives that may be given to the targeted industry. The indirect costs are the additional costs or lower quality products the users have to bear as the targeted industry learns to produce. These are often larger than the direct costs, especially when the targeted subsector fails to become competitive.

4.24 Another issue is sequencing versus leapfrogging, closely related to issues of incremental versus radical change. It is possible to work on sequential incremental change as long as there is interconnectedness. When the change is very radical, the advantages of sequencing are vitiated. We need to know more about connectedness and whether the learning along one technological trajectory is transferable to another. Some evidence, for example, suggests that what is important is not so much the experience with different vintages of specific technologies, since these may require different skills, but with learning how to make products with different levels of complexity. Thus, it may be useful to learn how to produce, say, audio cassette recorders before going into the production of videocassette recorders, which are much more complex and much more demanding.

4.25 Regarding the relevance of exports as a key element of a strategy to develop the electronics sector, an emerging issue is to what extent exporting might need to be re-examined in the context of the possible closing of export markets. A unified European Economic Community market in 1992 may be accompanied by the erection of trade barriers, a concern already fueled by new local-content requirements (e.g., the diffusion step of wafer fabrication). There is also some concern that the world may be moving toward regional trading blocks, which could determine and limit a country's trading options. More generally, if the world trading system deteriorates, countries may have to rely more on internal or regional markets than on international ones. That will have different implications for countries with small internal markets than for those with relatively larger internal markets because of the economies of scale necessary for efficient production.

4.26 Finally, there is an emerging concern with the issue of access to technology. In addition there is concern that there may be closing up or privatization of standards in the electronics industry, which may make it more difficult for developing countries to plug into electronics products industry trade. Some evidence indicates that it is getting harder to access the newest technology through licensing. In addition, there is much greater emphasis, especially by the U.S., on intellectual property rights, with patent infringers pursued more actively and forced to settle infringement claims. It is also now more difficult to "reverse engineer" technology, especially in the electronics sector. One of the principal ways around this is for developing-country firms to enter into strategic alliances with developed-country firms. However, for firms in developing countries to do this, they have to become stronger technologically, which means governments and firms are having to invest more in their own technological capability in order to bargain more effectively for access to newer technology.
BIBLIOGRAPHY


Riedel, James, 1974. The Industrialization of Hong Kong. Tubingen, Holland: JCB Mohr.


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