Industrial Policy and the Indian Electronics Industry

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ABSTRACT

Recently, production within India's Electronics sector amounted to a low $12 billion when compared to the global output of $1400 billion. The slow growth in the local industry is often judged to be the result of late economic liberalization within India. This thesis argues that the lagging growth is more a result of premature liberalization, and policies geared toward promoting the wrong types of firms. This thesis seeks to move past the sole focus of much research on the burgeoning software and services sector and evaluate the growth of electronics, software, and design services as closely linked sub-sectors. The analysis is therefore performed with direct considerations of the most successful types of firms, who very often are involved in multiple sub-sectors. The variations in firm size, national ownership, and orientation toward the domestic or international markets are all key considerations within this thesis, concerning the effect these characteristics have on the performance of firms and the industry as a whole. Additionally, this thesis addresses issues of great concern within the industry and India as a whole, such as preserving employment opportunities. India has followed a non-traditional approach to economic development, and it is the goal of this thesis to clarify that approach and assess its sustainability. Thus, the focus of the research is two-tiered: to provide an overall appraisal of current policy in India's Electronics Sector, considering capabilities in core industries (i.e. machinery) and the software industry; and to provide recommendations – as needed – for decreasing the import reliance on the high value-added electronic components such as LCDs, integrated circuits, and other complex assemblies.

Thesis Advisor: Alice Amsden
Title: Professor of Urban Studies and Planning

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1. Introduction

India is the second most populated country in the world, with a population of 1.13 billion, and it possesses one of the fastest growing economies in the world (CIA 2008). This tremendous growth has been fueled by India's significant global share of scientific and engineering talent. Yet, even this talent has not produced optimal gains for the country as a whole, and is most evident in lagging sectors such as the electronics industry. Within this federation of 29 states, as shown in Figure 1, there have been policies of both central and state governments that have guided development of the electronics industry. This thesis explores the possible role that industrial policy has played and can play in India's electronics industry, giving consideration to specific technologies, as well as considerations of industry and the economy as a whole.

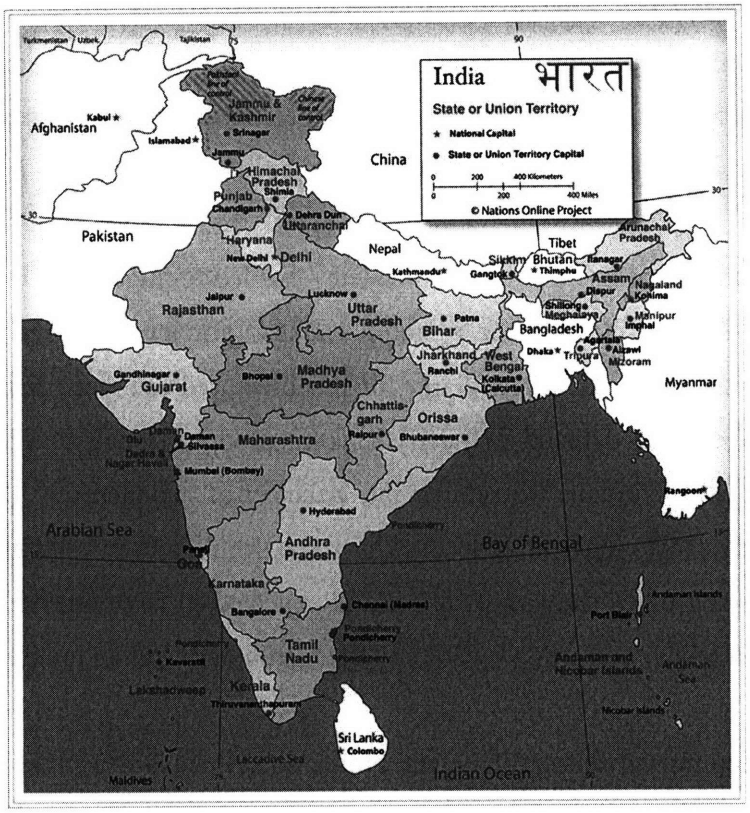

Figure 1: Map of India

Source: (Nations Online 2008)

1.1. Basics on India

India, with a current GDP growth of 8.5 percent per year, has steadily grown since the 1980s to the current level of $1.09 trillion in GDP (CIA 2008). Most of this growth has occurred on the coattails of the 500 PhDs, 200,000 engineers, 300,000 postgraduates, and 2.1 million other graduates entering the Indian workforce each year. These highly educated persons are both the product of and the impetus for the 250 universities, 1500 research institutions, and 10,000 higher education centers within the country (India Brand Equity Foundation 2006).

As of 2004, India has produced 690,000 graduates each year in the combined fields of science and engineering, compared to 525,000 in China, and only 425,000 in the United States (World Bank 2004). However, much of India's labor is still attracted to lower value added aspects of its economy. As a consequence, a massive 70 percent of Indians participate in an agricultural sector that accounts for only 15 percent of GDP (Mattoo and Stern 2003). Meanwhile, the services sector accounts for 51 percent of GDP, but only 22 percent of employment as of 2002 (Papola 2005). Scholars have suggested that the focus on services has led to jobless growth.

This structural unemployment – as it is often called – has led to huge wage inequities within the Indian economy. The result has been a small – albeit growing – ability to pay for locally provided products and services. Particularly for manufactured products, manufacturers do not experience a large enough demand to justify making products locally. Thus, India ends up importing these goods, further worsening the balance of payments. The issues of low unemployment and/or low wages are expected by some scholars to worsen within India. Much of this is based upon studies showing that India is expected to have one of the largest surplus populations in the working age group by 2020 (Confederation of Indian Industry 2003).

Despite India's seeming advantage in talent production, there are a great number of Indian citizens who accept jobs outside of the country, many of which are marginally related to Indian industry. This loss of talent, often termed "brain drain," has had a significant impact on India's knowledge based economy, and appears to have had a negative effect on many of India's production and export capabilities. This is especially troubling, when India is mounting an ever expanding trade deficit, which is at $22 billion USD as of June 2007 (India One Stop 2008).

Many Indian Institute of Technology (IIT) graduates have migrated to the U.S., for high-level working positions. For instance, a non-resident Indian (NRI) was one of the leaders in starting Sun Microsystems, a high-level computer maker. Upon their return to India though, a big problem has been that these NRIs receive unfavorable treatment from local residents (National Research Council 2007). There is a significant opportunity to encourage the return of these students, given that nearly 80,000 students were studying in the US in 2006, and that India sends a larger number of students to the US than any other country (National Research Council 2007).

With a fast growing young population, India faces the danger that it will see a mass export of its young persons in the near future, should they not be able to correct such structural unemployment. Even as the issue of structural unemployment may suggest some problems created through government policies, the strategy India should now pursue is uncertain. Increasing amounts of evidence suggests that India has actually run into a skills shortage in high-end services (Surowiecki 2007), indicating a failure to optimize employment within the high performance "services" sector. The issues of structural unemployment, industrial growth, and general economic success are key considerations for assessing past and present industrial policy in India.

1.2. Problem

For developing countries, there have been several government strategies for developing a domestic electronics industry. Most of these countries, including Korea and Brazil, have prohibited imports of electronics to protect the suppliers of their nascent industry. A previous generation of developing countries, which includes Taiwan, actively supported the export of electronics goods and services once they opened up their domestic market to imports.

India has pursued a much more active role within the electronics industry than many of its competitors and predecessors. The industry has maintained a relatively slow growth since its infancy, and has not developed significantly since the Indian government began a period of economic liberalization within the industry. In the initial stages of the industry's development –

the 1960s and 1970s – government policies were geared toward direct involvement in production, through several state owned enterprises. In the 1980s significant economic liberalization occurred in the industry, meaning that the government opened up more to foreign capital and investments, reduced barriers to imports, and allowed greater private sector participation.

This economic liberalization has been credited for India's recent success in GDP growth in the economy as a whole. India's electronics industry, however, must be evaluated separately from other sectors, because the initial government support and the initial economic liberalization came at different time periods for the electronics industry than for the rest of the economy. The electronics industry was the first industry within India, to receive substantial government support. It was also the first to experience significant economic liberalization, which began in the early 1980s for the electronics industry, whereas other sectors of the economy experienced economic liberalization until 1991.

There is a need to evaluate the effect this liberalization has had on the electronics industry specifically, and assess the long-term viability of the industry under these liberal policies. India's policies for developing a domestic electronics industry have produced fewer manufacturing capabilities than other developing countries. The current production level for the Indian electronics industry is only 0.7 percent of the total global output (Plan B Manufacturing Ltd. 2006). Although Indian firms have expanded production within the electronics industry, they only account for an average of 22 percent of the value for electronic goods. This falls well below the global average of 40 percent value-added (Plan B Manufacturing Ltd. 2006).

This lack of manufacturing capabilities is dire, given that the experience of other countries has shown that a single electronics manufacturing center helps create 15 supporting or related industries, including assembly and packaging centers, which generate significant employment because of their labor intensity (India Brand Equity Foundation 2007). With such massive imports of electronics components, India faces the prospect of becoming like Mexico, which was the first region developed by an industry for electronics manufacturing. Mexico has come to import more than 90 percent of components for use in electronic products, resulting in higher

costs for the original equipment manufacturer and the eventual shift in production to countries like China (Carbone 2005).

Coinciding with India's trend of performing less of the production has been a growth in software production and electronics design services. Both of these sectors are increasingly integrated with electronics manufacturing. Because of this integration, the absence of domestic manufacturing at the high-level electronics level may also worsen design capabilities. Ensuring that Indian firms remain viable in this industry requires policies to address not only market failures, but also coordination and information policies.

The purpose of this thesis is to illustrate the results and limitations of Indian governmental interventions in the electronics industry. In particular, this thesis is concerned with the effect of liberalization on the electronics industry in India, and the sustainability of the current approach. Finally, this thesis seeks to address these issues by looking at the varied performance of different types of firms, as well as the policies that may have guided these firms' behavior.

1.3. Hypothesis

This thesis will concern three major factors regarding firms within India's electronics sector, to discern the effect of government interventions, particularly those policies aimed at economic liberalization. The factors of firm size, national ownership, and outward orientation (exports vs. domestic sales), represent the primary changes within the policies geared toward liberalization. This thesis will therefore test the following assumptions for India's electronics industry, as it relates to these three factors:

1. Investments have been greater for small firms, but performance has been better for larger firms.

2. Investments have been greater and performance has been better for nationally-owned firms and domestic privately-owned firms, in comparison to foreign firms.

3. Investments have been greater for companies pursuing the international market, but performance has been better for those pursuing the domestic market.

The tests of this hypothesis builds upon previous research of the Indian economy as a whole (Kumar and Aggarwal 2005). Unlike the previous study, this thesis focuses solely on the electronics industry within India, and considers the effects of liberalization beginning in the early 1980s, as opposed to 1991. Additionally, this thesis considers the role of government aid and support, before and after liberalization. In the previous study, investments were considered only as they related to the firm (i.e. the amount of R&D activity a firm conducts). In this thesis though, investments are considered as both the activity of the firm and government investments targeted toward specific firms.

The conclusions drawn are based upon the results of this prior work, and other literature regarding the characteristics which determine a firm's success. The first hypothesis statement is that investments have been greater in small firms, which is based upon a long literature review suggesting that small firms are inefficient in both production and innovation, when compared to large firms. Schumpeter led the way in stating that monopoly power can bring about significant innovation (Schumpeter 1942), and was followed by economists suggesting that large firms were proportionally more innovative than small firms (Galbraith 1952). Further work has contradicted these other works, concluding that small firms were more competitive than firms under monopolistic conditions (Arrow 1962). Based upon this insight, the idea of performance in this thesis incorporates a long- term view that includes the capacity to upgrade to newer technologies, not just achieve lower prices. This view is validated by Dasgupta and Stiglitz who argued that industries with higher levels of concentration and larger firms yielded higher levels of research intensity (Dasgupta and Stiglitz 1980).

Regarding firm nationality, many scholars have encouraged government support of nationally-owned and privately-owned domestic firms, over private firms. The second hypothesis statement is based upon literature showing the efficacy of nationally owned firms in promoting cost-saving coordination within an industry (Amsden 2003). There are, however, some scholars who argue that government support through activities such as production, subsidies, and procurement,

simply prolongs inefficiencies or leads domestic firms to maintain high prices (Evenett 2002). This second hypothesis statement therefore relies on the view that these firms have incentives other than competition, such as profit margins and continued support that cause them to keep prices low and remain efficient (Amsden 2004).

The market orientation of firms has been researched by several economists to study the effects it has on the quality of products and the intensity of the research performed in-house. The third hypothesis statement builds upon research, suggesting that firms conduct more R&D when they are oriented toward the international market (Goldar and Renganathan 1998). However, research suggests that these outwardly oriented firms may be less efficient, and heavily reliant on imported components for their final products, if not prepared to export (Amsden 2003). Therefore, the third hypothesis statement, assumes that Indian electronics firms have greater investments because of a large export market, but the return on investment is low.

This thesis supposes that liberalization policies have been counter to the promotion of those firms with the greatest level of performance, as distinct from those firms who invest the most resources. India's low global share of production within the electronics industry is therefore, largely a consequence of government policies that have promoted the wrong type of firms at the wrong times. It is expected that these policies have not adequately promoted the markets most profitable sectors, and have not been oriented toward the greatest opportunities for market expansion.

1.4. Methodology

To evaluate these government policies, this thesis focuses on three broad areas: government aid and support, regulation, and government investments in the future. The indicators used are chosen from various sources including, the European Commission Innovation Scoreboard, and the OECD Regulatory Database. These government policy indicators are shown in Table 1.

The method used in this thesis looks not only at the effects of these policies on industry performance, but also to the effects these policies have on different types of firms within the

industry. To accomplish this task, a time-series analysis over the period of 1960 to the present is employed to discern the effect of these policies over time. There is also a comparison of the production within India's many different states. Given that the state governments are heavily encouraged to set up electronics development corporations, it is essential to look at the differing policies that these states choose to abide by. The chosen policies of each state are very important, as studies have shown that Indian-states have surprisingly little migration between them, thus very little knowledge transfer of best industry practices (Clark and Wolcott 2003). Particular attention is given to the immediate before and after of policies geared toward significant economic liberalization.

After determining the general relationship between the government policies and the success of these firms (as measured by the value added as a percentage of manufacturing and process time improvements amongst other factors), I relate the success of these firms to their characteristics. The use of these characteristics builds upon a previous study of Indian Industry (Kumar and Aggarwal 2005), but gives specific consideration to the electronics sector in this study. These characteristics are also shown in Table 1.

Table 1: Government Policy Indicators and Characteristics of Firms

Government Policy Indicators	Characteristics of Firms
Aid	Firm Size (sales of firms)
Manufacturing subsidies as a share of value added	Firm Investments (R&D and training)
Public procurement as a share of total sales	National Ownership (Percentage of foreign equity)
	Outward Orientation (Exports of goods as a proportion of sales)
Regulation	
Product Regulation	
Economic Regulation	
Labor Market Regulation	
Investments in the future	
Public R&D Expenditures	
Training and Education Expenditures	

Source: Author

This analysis will cover the period from 1960 to the present, focusing on the time before liberalization and the time after liberalization. The thesis will concentrate on development within the Indian electronics sector. The primary sources from which this data will be obtained are governmental statistics, official international sources, broker and analyst reports, business information libraries and databases, and other reports and databases.

This thesis does not quantitatively consider the quality of the products and services provided. It is decided in this study that sales, value-added in manufacturing and process time improvements are fully indicative of a firm's performance, and reflective of the quality of products and services provided. Additionally, this thesis does not qualitatively consider the transfer of knowledge between domestic firms. Most of the data regarding the transfer of technological knowledge is presented as licenses issued by government labs to private firms, licensing from foreign firms to domestic firms, and finally collaborations and joint ventures of domestic firms with foreign firms. This thesis therefore qualitatively assesses the coordination amongst domestic firms, considering policies that explicitly pushed for such coordination.

Finally, the results of this analysis will be tested against the said hypotheses, using the carefully selected indicators. Based upon the insights provided, this thesis will provide recommendations regarding the policies that should be pursued to promote India's electronics industry.

1.5. Outline

This paper assesses the effect of both current and past policies on the Indian Electronics Industry, and is aimed at providing insights for development scholars interested in technological development and industrial policy, as well as decision makers who may promote such policies. To accomplish this task, I have established a framework which will give some correlation between the policies pursued, and the success of the industry, while yielding specific insights to the types of firms that have been most successful and should be most encouraged.

I expect that the analysis of this sector, over the period 1960 to the present, will demonstrate that the success and failures of these major firms may be attributed to policies geared toward specific types of firms rather than policies influencing the economy broadly (i.e. policies altering the exchange rate). This hypothesis will be tested using statistics that cover the industry as a whole, as well as statistics concerning specific types of firms.

The following chapters provide an overview of the Indian electronics industry, and seek to assess the validity of many technological development theories by relating them to the experience of India's electronics industry.

Chapter Two provides basic information regarding the electronics technology of interest, and accomplishes a basic review of the policies that have aided or abetted the electronics industry and other high-tech sectors within developing countries.

Chapter Three reviews the history of Indian industrial policy, giving special emphasis to policies that affected the electronics sector most. This chapter divides the pursuit of these policies into three subsequent phases, leaving the most recent policy changes and developments within the industry for the next chapter.

Chapter Four maps out the current global market, and includes an in-depth look at the current electronics industry in India. The chapter focuses on the largest subsectors within the Indian electronics sector, and particularly highlights the rise of India's design services within this Industry.

Chapter Five includes an analysis with respect to the hypothesis, and a results summary of the policies that have helped or hindered the growth of the electronics industry in India. This chapter also includes an assessment of India's service based approach in this industry, outlining the major challenges, and providing some short-term and long-term recommendations to improve the total efficiency of India's electronics industry. An important goal of this thesis is to provide new insights of relevance regarding the field of technological development. Recommendations for future work are made based upon the achievements of this goal.

2. Technology and Economic Development

2.1. The Technology

The electronics market can be thought of as consisting of two major groups, based on the required technological capabilities in production and design (see Appendix C). The first group, being that of higher-level electronics is made up of essentially those components and processes that become the building blocks for the electronic devices consumers interact with, and are more or less specific to those devices. Integrated Circuits and components such as picture tubes and liquid crystal displays (LCDs) may be thought of as belonging to this group. The second group, being that of lower level electronics, consists of the production and processes that allows for higher-level electronics to be assembled along with other components to make a product ready for consumer use.

For analyzing India's historic stake in the electronics industry, this thesis focuses on audio and video products (i.e. televisions and radio receivers), computers and software, specialized electronics, and the emergence of telecommunications products in later time periods. This section therefore covers the basics of electronics technology, and outlines the major players in the global market.

2.1.1. Integrated Circuits

Integrated Circuits are the foundation of nearly all electronics products. Computers, consumer electronics, and specialized equipment used in fields such as medicine and transportation, all operate based upon this technology. The manufacturing process for integrated circuits is very research intensive, and requires ever increasing amounts of capital. According to the Semiconductor Industry Association (SIA), it now costs up to $4 billion to build a state of the art facility for the production of these circuits.

Integrated Circuits are developed by etching electronics circuits on thinly sliced wafers of silicon. This process is very meticulous, and first requires that all the silicon wafers be refined and processed in a "clean room" that is a room essentially devoid of any dust particles. First a silicon crystal is grown, then cut into wafers less than a millimeter thick. Several steps are then performed, to allow each circuit to conduct electricity. Not shown here is the back-end process, where each individual circuit is cut from the wafer, processed, and packaged.

These integrated circuits contain many different electronic components, including transistors and capacitors, on a single chip. There are mainly three types of integrated circuits. These are memory devices used to store data, logic devices to perform calculations, and some combination of the previous two. Though integrated circuits are actually part of a slightly larger semiconductor market, this thesis treats integrated circuits as the entire semiconductor market. These integrated circuits are produced in unpackaged form on chips as shown in Figure 2, but there are entire processes dedicated to packaging these chips for use with other devices.

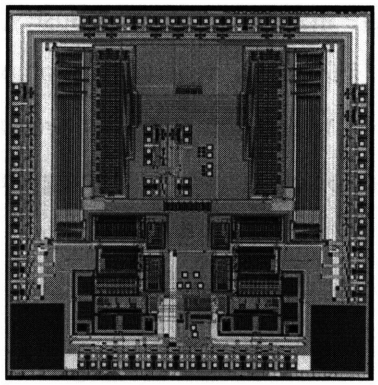

Figure 2: Unpackaged Integrated Circuit

Source: (Wikipedia 2007)

Assembling ICs with other components is used in the completion of a finished product. These components include LCDs, picture tubes, and various industrial components that are essential for creating products that can be readily used.

2.1.2. Finished Electronics Product

As already described, this thesis is concerned with electronics products in which India has demonstrated a historic stake. Among these are, or have been, black and white television sets, color television sets, radios, and telecommunications equipment, including cell phones. Computers and Software have a unique development story, one which is very relevant to the development of the industry as a whole. Figure 3 shows some of the consumer electronics that are assembled from various electronics products, including integrated circuits.

Figure 3: Finished Consumer Electronics Products

Source: (Four Korners 2008)

2.2. Industrial Upgrading in Developing Countries

The primary focus of development scholars has been minimizing transaction costs, by ensuring perfectly free trade and eliminating those practices deemed uncompetitive. This focus on minimizing transaction costs implies that a country should support those fields in which it already has an advantage. Under this school of thought – known as neoliberal economics – developing countries are limited to static comparative advantage, meaning that they should only produce in those industries where they have a current advantage. This focus on transaction costs and static comparative advantage ignores the success of earlier developing countries, including Taiwan and Japan, in promoting a domestic electronics industry. These countries developed a

profitable domestic electronics sector, despite entering the sector years after its beginning. Unfortunately most economic studies have underrepresented the policies that promoted growth within high-tech sectors like electronics. These countries sought dynamic-, not static-, comparative advantage, meaning that their governments supported the build-up of nascent industries like electronics. The build up of domestic industries, which are years behind the technological frontier, is referred to as support for infant industries. Such support, required delayed gratification, but has led to growth rates and technological capabilities that would not have otherwise been achieved (Amsden 2003).

The improvement of technological capabilities related to production, project execution, and innovation, have been more responsible for building developing country wealth than the minimization of transaction costs (see Appendix C). The production capabilities of trouble shooting and quality control are often improved for all sectors as a country has upgraded into more advanced sectors (Amsden 1997). The move from lower tech-sectors such as petrochemicals and steel, forces developing countries to upgrade skills in project execution, such as the procurement of inputs, coordination of suppliers, and training of personnel. Lastly, the ability to innovate through process optimization and through basic research (at a more advanced state) has been advanced through the pursuit of dynamic comparative advantage. These skills, in particular the skills or research and innovation, have allowed countries to survive the many instances of what Joseph Schumpeter called "creative destruction" in the electronics industry.

A study on the effects of economic liberalization within the electronics industry, must consider that many of these capabilities are attained only through temporary deviations from minimizing transaction costs. In the electronics sector, many of these capabilities are tacit, such that the effects of developing these skills may not be immediately seen. Therefore, many of the policies in place before liberalization, which focused on the build-up of these skills, must be evaluated with beyond the period of initial liberalization. Unlike many other studies, this thesis looks past the immediate trends following liberalization and to longer-term trends in order to better discern the effects of past policies after economic liberalization.

2.2.1. Import Substitution

Countries like Taiwan and Japan have faced one major limitation in developing their electronics industries, which is to maintain sufficient foreign exchange throughout this upgrading process. Maintaining extensive foreign exchange reserves was important to ensure that other sectors, which relied on imports, held a stable currency with which to purchase their goods. Thus the governments guided the new industry to import less than it exported.

To accomplish this goal, developing countries used proactive measures of first cutting back on imports. Since it was multinational corporations (MNCs) that performed most of the exporting, considering the domestic industry was unprepared to export, foreign exchange could not be earned through increasing exports. Instead, the governments limited imports of certain items, and established policies to aid in producing domestic versions of what was formerly imported. These policies included the use of subsidies and selective tariffs to make the domestic product more economically viable.

The concept of upgrading through the selective substitution of products formerly imported, is referred to as import substitution, and is very much in line with the Singer-Prebisch thesis, which focuses on the promotion of infant industries (Prebisch 1950). This strategy was more effective for many countries than the use of wide-reaching tariffs, which often led to the use of knock-down kits. These knock down kits were a collection of unassembled electronics components, which were locally assembled into finished products, in order to circumvent the high tariffs on those finished goods.

This import substitution approach was often complemented by policies that discouraged foreign direct investment (FDI), which is the lasting investment of a multinational corporation in a foreign firm. These developing countries opposed FDI, on the grounds that domestic firms would better withstand the global shocks, whereas firms with heavy FDI with experience significant capital flight after such shocks. Additionally, developing countries promoted discouraged FDI, on the grounds that it provided lower opportunity for domestic employment.

Finally, these countries sought to enter these markets not as leaders, but as fast followers, who produced these high-tech products once having reached a point of maturity. This is the point when profits have fallen dramatically, but sales have risen dramatically. While simultaneously prohibiting imports of finished products, and important components for these products, developing countries overvalued their currencies to help with the import of capital goods that would support long-term growth.

2.2.2. Export-Led Growth

Once the domestic industry was judged adequately developed, the governments in these industries began to promote exports, which also helped their foreign exchange reserves. This ability to export high quality products was aided by the pent-up international demand, occurring as a result of developing countries focusing on their domestic markets during the time of import substitution.

During this export-led growth, developing countries initially competed based on wages. However, it was not possible for this strategy to work forever, since there were almost always countries who could offer lower wages. Therefore, many of these countries kept some import substitution measures in place, to ensure that they could compete on efficiency rather than wages. By promoting coordination and the sharing of capital between firms, developing countries were able to save costs, allowing them to spend more on worker training that increased efficiency, instead of lowering wages (Amsden 2004).

To gain access to these international markets, developing countries were required to open their domestic market. To mitigate the potentially damaging effects that this burst in international completion could have on the domestic industry, many developing countries devalued the local currency. This allowed for the governments to better facilitate exports, while protecting against heavy imports.

However, developing countries did not rely on these larger macroeconomic factors such as the exchange rate, to ensure that they could accomplish export-led growth. The exchange rates were

subject to random fluctuations that could easily damage the ability to export, if there were no other measures in place. Furthermore, excessive devaluations of the local currency led to abnormally high demand in some sectors, resulting in high levels of inflation within some developing countries.

The most important factor for developing countries in achieving export-led growth was timing. These countries waited until they were prepared for export-led growth before they succumbed to the major pre-conditions of liberalization, such as opening their markets to imports. In this way, they were able to ensure positive growth, increase employment, and income.

2.2.3. Measures of Government Support within the Electronics Sector

The electronics market has required fast ramp-up from its major players, and thus more substantial government support to overcome the fast drops in profit margins. The huge fixed costs in the high-tech arena, and electronics production in particular, have been complemented with very low marginal costs. Therefore, it has been more advantageous for many developing countries to encourage greater local investments in high-tech areas such as electronics, since more benefits are reaped with greater economies of scale.

Table 2 shows the roles played by different governments in their initial development of the electronics sector. These roles included fiscal and financial incentives that they used to promote industrial R&D, operation of state owned enterprises, and government procurement of products and services. The major differences in between newer developing countries (i.e. China and India), and earlier developing countries (i.e. Japan and Taiwan) are shown in the highlighted potion of Table 2. The differences are the level of direct participation of the government in production and services, the stance toward FDI, the stance toward firm size, and the degree of human resource support dedicated to the industry. This human resource support includes government support in recruitment, training, and retention of highly skilled employees.

The only significant difference between India and China has been that China has a more favorable position to firms of large market share, while India has been heavily anti-trust oriented.

In comparison to Japan and Taiwan, the most successful developing countries in this industry, India and China differ mainly in their low use of special human resource strategies. India has been heavily involved in actual production, in addition to being anti-trust oriented, and with low human resource strategies. In comparison to Taiwan, India only differs significantly regarding the extent to which it employs human resource strategies.

Table 2: The Role of Government by Main Instruments

Country	Trade Protection	Public R&D	Fiscal/financial incentive	Government Procurement	Direct Participation	Direct foreign investment control	Industrial Organization	Special Human Resource Strategies
India	High	High	High	High	High	High	Anti	Low
China	High	High	High	High	High	High	Pro	Low
Japan	High	Medium	High	High	Low	High	Pro	High
Taiwan	High	High	High	High	Medium	Medium	Anti	High

Source: (Wellenius et al. 1993)

These different governmental roles in establishing ownership characteristics (the support of public, private, or foreign ownership), the stance toward large firms, and the different employment of human resource strategies, reaffirm the focus of this thesis. In this thesis the success of governmental intervention are evaluated with respect to the changes in those roles after economic liberalization.

Many of these changes after liberalization have come in through incentives encourage or discourage foreign direct investment. Several of these policies for promoting, as well as discouraging foreign direct investment are summarized in Table 3. Many of the negative incentives for discouraging foreign direct investment are now violations of the WTO's Trade Related Investment Measures (TRIMS) Agreement, to which India is a signatory. The positive incentives may be used to promote not only FDI, but also to promote domestic firms instead (Amsden 2005). It is the use of these positive incentives for promoting domestic firms, which characterizes the newest mode of import substitution. Import substitution in high-tech industry has consisted of subsidies for public and private R&D, tax breaks, as well as financially

favorable conditions for residents of science parks and technology parks. This new mode of import substitution is meant to support specific firms, in exchange for their accomplishing specific tasks.

Table 3: FDI Policies

Positive Incentives	Negative Incentives
Guarantee against Nationalization	Nationalization or appropriation
Tax Holidays	Double Taxation
Tax treaties to avoid double taxation	Domestic content requirements
Exemptions on import duties for capital and intermediate goods	Domestic employment restrictions
Exemptions or relaxation of rules in priority sectors	Export requirements
Subsidies (i.e. reduced rent on land; accelerated depreciation)	Foreign exchange requirements
Special promotion of exports	License screening
	Foreign equity requirements
	Land ownership restrictions
	Restrictions on remittances of profits
	Restrictions on liquidation of the company

Source: (Various Sources)

3. Development of Indian Electronics

3.1. History of Indian Industrial Policy

Following its political independence in 1949, India wanted to achieve greater economic independence as well. Though wanting to immediately practice import substitution, India opted – for reasons of insufficient technological experience – to allow MNCs considerable leeway in the domestic market. These MNCs gained considerable market share, to the eventual dismay of Indian policymakers.

This led to the industrial policies of the 1960s and 1970s, in which India was very focused on self-reliance, promoting indigenization of much of the technology it formerly imported. Coupled with this import substitution were several other industrial restrictions, which limited the size of a firm and imposed foreign exchange requirements.

In the wake of oil shocks in the early 1980s it was realized that the country needed to increase exports considerably, and it was felt that domestic electronics firms would not be up to the task alone. Thus, several changes to industrial policy in the electronics sector were introduced. India opened up to foreign collaborations, by easing restrictions on the Foreign Exchange Regulation Act (FERA) for high-level technology like electronics and for 100% export-oriented units. The FERA had previously imposed strict regulations on transactions that impacted foreign exchange, as part of an overall strategy to direct the usage of foreign exchange resources.

In 1991, the financial crisis corresponding with the fall of the Soviet Union (a sizeable client of Indian industry), and the Gulf War which led to a massive exodus of Indians working in the region, curtailed the flow of this foreign exchange to India. Under these conditions, India moved to relax much of its economic and administrative regulations for the entire economy, not just electronics. First, the licensing Raj, a set of rules and regulations that discourage both foreign and private investment, was banished. The Monopoly and Restrictive Trade Practices Act

(MRTP), which previously imposed strict limits on the market share a firm could hold, was then abandoned. Lastly, many of the restrictions on imports were alleviated.

Throughout this entire process though, Indian Industry has maintained structural support for both small firms and public enterprises. Even though active support for these industries has dwindled, there are still various economic regulations giving preference to small scale industries (SSI) for certain production tasks, and limiting other production tasks to public sector enterprises (PSEs).

3.1.1. Small Scale Industry (SSI)

SSI has been promoted since very early on in Indian industrial policy, back to the time of independence, although this promotion has lost some intensity in recent years. The rationale for promoting these SSIs is that they help to develop extremely underdeveloped areas, increase employment and further exports. The support and strategic targeting of these SSIs has led to them accounting for around 38 percent of total manufacturing exports as late as 2002.

To promote these industries, the Indian government has limited participation in certain sectors to SSI firms, provided land at cheaper rates, granted easier access to credit, and exempted these firms from excise duties and sales tax. The National Small Industries Corporation (NSIC), which has provided infrastructure, guidance, and training for these SSIs, has also used government resources to market SSI products. Many state governments have also given additional benefits to support these SSIs (2004).

3.1.2. Public Sector Enterprises (PSEs)

To promote certain sectoral activities, India has employed public sector enterprises (PSEs), which are state owned enterprises, and which currently number 253 units. For these units, control may lie with either the central or state governments. The historic rationale for the existence of these PSEs is that they may better embark upon ventures with high levels of risk and capital intensity, in addition to long gestation periods. Throughout the years of the licensing raj, many sectors were limited strictly to participation by PSEs, thus PSEs have traditionally accounted for a large percentage of domestic manufacturing.

In 1997, the government identified a set of PSEs that performed well enough to warrant being given a special status and set of benefits. There is now a total of 12 Navratnas, as they are called, and their special status allows them to enter joint ventures, form alliances, and establish subsidiaries in foreign countries, among other benefits.

3.1.3. Special Zones

In addition to promoting the development of advanced technology and techniques, Indian policies have established select zones to promote the export of products. India set up its first export processing zone (EPZ) in 1965, to encourage the export of goods produced within India. Although there was the expectation that firms within these zones would export 100 percent of their products, the firms were allowed to sell some percentage of their goods within the domestic tariff area, which was treated as a foreign country for the purpose of exports. These firms were given incentives such as tax breaks and tax holidays. Many other informal benefits were also extended to firms located within EPZs. For instance, the minimum wage rates have not always been enforced, and manufacturers have been given government protection from strikes. The first electronics-oriented EPZ was established in Bombay in the early 1970s – the Santa Cruz Electronics Export Processing Zone (SEEPZ).

Export Oriented Units (EOU), are isolated units that can be set up in a wider variety of areas, operating under almost the same principles as these EPZs. As of 2003, India has employed the use of Special Economic Zones (SEZs) which are still export oriented but have operated differently from either EPZs or EOUs. Unlike the other schemes, there are no minimum investment limits for SEZs. Additionally, SEZs can obtain custom clearance for imports within the zone itself, and they enjoy greater infrastructure provisions than EPZs or EOUs.

3.1.4. Technology Promotion Schemes

In addition to the export processing zones, there have been several government schemes dedicated to discovering advanced production and process techniques. For the electronics sector, this has included: Science and Technology Parks, Industrial Parks, Software Technology Parks

(STP), and Electronics and Hardware Technology Parks (EHTP). These parks have been established by central and state governments, as well as private sector organizations.

3.2. History of the Indian Electronics Sector

While the electronics industry within India had a growth rate of less than 10 percent in the 1960s and 1970s, this growth grew to nearly 25 percent in the early 1980s. Concomitant with many of the changes introduced in the mid-1980s, including the openings to foreign collaboration and easing of FERA restrictions, this sector has grown at a rate above 30 percent (Wellenius et al. 1993). Yet, in comparison to the industry globally, the Indian electronics sector has remained stagnant.

3.2.1. First Phase – 1960s and 1970s

The policies of the 1960s and early 1970s were geared toward promoting indigenous production. In the 1960s, the main impetus for this indigenous production was the needs of the defense industry to have a secure electronics industry. In the early 1970s, the Electronics Commission and the Department of Electronics were established. Leading into this time period, IBM had previously accounted for approximately 70% of the Indian computer market, from the years of 1960-1972 (Dedrick and Kraemer 1993). These two organizations decided that large firms like IBM were selling in the local market, but without locating manufacturing operations within India. Moreover, IBM was selling computer models that were obsolete elsewhere, using imported equipment. Consequently, IBM was asked by the Indian government to increase their manufacturing operations, and since it did not, IBM ended its operations (temporarily) within India in 1978.

A follow-on consequence to the antipathy directed at large foreign firms was an antipathy to large firms in general. Thus, there were newly established regulations prohibiting various types of imports, in addition to regulations prohibiting even large, privately-owned domestic firms from participating in certain sub-sectors. Large firms were restricted under the MRTP and foreign firms were restricted under the licensing Raj from diversifying into many of these

protected sub-sectors. Specifically, those products and technologies that were considered high-tech and relatively capital intensive were restricted to PSEs. Activity considered low-tech, such as the production of electronic components and the assemblage of consumer electronics, was restricted to SSIs.

The import substitution process began with those goods that were both most mature, and that would ensure long-term growth: India practiced indigenization of electronic capital goods to the greatest degree. Imports of capital equipment were severely restricted, requiring many steps to obtain permission for imports. Consequently, most of the growth during this period was related to this electronic capital goods sub-sector which had a 40 percent growth rate, and also accounted for the greatest share in total production (Joseph 2004).

To acquire the knowledge IBM had, the Center for Scientific and Industrial Research (CISR) was set up, operating several laboratories dedicated to the pursuit of electronics R&D. To move into the production of electronic components and devices for the computer sector and other sectors, two of India's public sector units took the lead. Bharat Electronics Limited (BEL) was entrusted with developing the necessary technology for picture tubes, and Electronics Corporation of India Limited (ECIL) replaced IBM in the computer sector. The Ministry of Defense was responsible for BEL, and simultaneously enforced many of the restrictions on other firms entering the sector. From 1973 to 1977 ECIL grew its market share from 43 percent to 50 percent, yet had lost a significant amount of this share by the end of the decade. Although, at its peak ECIL produced nearly 100 different products, only four of these products were eventually sold to the private sector (Evans 1992).

ECIL was characteristic of the government's promotion of PSEs through the 1960s and 1970s. In 1975, there were four public sector units in electronics with production revenues of 1780 million rupees. There was only one private sector unit with production revenues of 590 million rupees, and numerous medium and small-scale units with production revenues of 1270 million rupees. Only later in the 1970s did private firms become involved, such as ICL, a joint venture between Tata and Burroughs, which would take the lead from ECIL (Chee-Wah 2006).

Small-scale firms participated in assembling finished consumer electronics products like black and white TVs. Specifically, 50 percent of the TV industry was set aside for small-scale sector participation. Even more small-scale firms would enter the industry, with approximately 87 percent of the 77 licenses issued in 1972-1973 going to small scale firms. Operating mainly by assembling kits from imported components, these firms imported picture tubes that accounted 40 percent of the black and white TVs value (Guhathakurta 1994). Having no experience in this industry though, and unable to participate in foreign collaborations, many small scale firms were forced to copy foreign designs. Due to lack of experience in production processes, these firms had both higher prices and older technology.

To facilitate exports, India set up the Santacruz Electronic Export Processing Zone (SEEPZ) in 1972. It also established entry standards – although not performance standards – requiring that all production be exported and be of at least 20 percent value added. Contrary to the rest of the industry, the units in the SEEPZ were allowed to import capital goods, as well as raw materials and components without a duty charge and without having to acquire a license. Furthermore, within the SEEPZ, firms that were 100 percent foreign owned could set up operations.

At this time, the policies directed toward the software sector were counter to the experience in other areas of Indian electronics. While computer electronics were subject to high tariffs or large non-tariff barriers such as restrictions on Foreign Direct Investment (FDI), firms that were exporting software could import electronics hardware freely.

3.2.2. Second Phase - 1980s

In general, this time period coincided with a great push for liberalization within Indian electronics. The electronics industry though, which was the first industry to receive substantial government support, was also the first sector of the Indian economy to be significantly liberalized. The central government issued policies specifically targeted toward the electronics sector, starting with the Policy on Electronics Components in 1981. This was followed by the New Computer Policy of 1984, the Integrated Policy Measures in Electronics in 1985, and the

Software Policy in 1986 (See Appendix A). The rest of the economy would not experience significant economic liberalization until 1991.

These policies gave manufacturers easier access to imported components and capital, increased the threshold by which a large firm was considered monopolistic under the MRTP, and eased restrictions on foreign collaboration that only allowed for up to 40 percent foreign equity. The royalty ceiling was also raised from 5 to 8 percent, leading to nearly 200 foreign collaborations per year in the late 1980s compared with less than 20 per year in the mid-1970s (Wellenius et al. 1993).

At this time, the growth in India's electronics industry was greater than all other industrial sectors. From 1980-1985, its compound annual growth rate (CAGR) was 25 percent and grew to 35 percent for 1985-1990 (Department of Information Technology, Data Bank & Information Division 1993). Most of the activity was in consumer electronics, a sector in which small-scale firms held a significant share. The relative strength of the consumer electronics sector was unique to India, representing only 11 percent of production in other developing countries, but over 30 percent for India throughout the 1980s (Alam 1990). As of 1983, the combination of radios and TV receivers accounted for almost 80 percent of total consumer electronics, while tape recorders accounted for an additional 10 percent (Agarwal 1985).

However, after this period of liberalization, roughly 80 percent of electronics components were imported, and most foreign direct investment resulted in the assembly of imported kits (Alam 1990). Small scale firms led the process of assembling knock down kits. Coinciding with this was a decline in exports, decline in the share of domestic production, and a decline in R&D activities (Department of Electronics 1988).

To further promote the software sector, an explicit policy was issued in 1986 that pushed for greater software exports. The liberalization occurring two years before in the computer industry was intended to aid the software industry, since software developers formerly had to pay much higher than international prices for the tools they needed.

3.2.3. Third Phase - 1990s

In the 1990s, PSEs accounted for approximately 35 percent of the electronics sector output, while SSIs, who accounted for most of the 3,000 firms, produced only 30 percent of the total output (Wellenius et al. 1993).

The telecommunications and industrial electronics sectors had been led quite adequately by PSEs such as the Indian Telephone Industries and Hindustan Cables Limited, but the PSEs within the integrated circuits and components industry experienced low levels of domestic demand. The main PSEs producing integrated circuits and components were BEL, a PSE leading production in small scale and medium scale integrated circuits, and Semiconductor Complex Limited (SCL), a company specializing in very large scale integration.

In the case of the lower-level chips produced by BEL, most of their chips were used only by two other PSEs, Electronics Corporation of India Limited (ECIL) and KELTRON. Other firms, mostly SSIs, continued to use imported ICs. There had been a rise in color television consumption that overtook black and white televisions as the main engine of growth. The production of radios was also an important driver for the industry. However, there was still a very small share of ICs and other high value components for these products being manufactured in India.

During this time, the lack of exports forced a 25 percent rise in tariffs on the computer industry (Joseph 2004). Great efforts were extended to promote the software industry's growth and exports, primarily the introduction of many software technology parks (STP) in 1991. These parks allowed for tax holidays and duty-free imports, as well as easier clearance for foreign equity and subcontracting. From 1991 until 2000, the total exports of ICTs in India increased from $164 million to $3.9 billion, with STP units increasing from a share of 0 percent to a share of 68 percent of these exports (Joseph 2002).

4. Current Status of Indian Electronics

The current world market for electronics is quite large and growing at a rate twice that of GDP, reaching a world output of $1400 billion in 2005, with an expected output of $ 2100 billion by 2010 (KPMG 2005). Within this market, the major players thus far have been Europe, Japan, and the countries within the Asia-Pacific Region that are India's main competitors.

Of the worldwide production though, India's current production still remains low, currently at $16 billion, even though it is expected to reach $40 billion by 2010. Of the current production, India only exports about 10-15 percent, a great contrast to India's recent pursuit of export-led growth (ELCINA Research 2006).

4.1. Electronic Components

4.1.1. Integrated Circuits

With specific regards to the IC market, the documented sales are at $250 billion, with the greatest growth in sales coming from the Asia-Pacific Markets (Semiconductor Industry Association 2008a). The governments of Taiwan, China, and Malaysia, as well as India, have significant differences in their industry involvement. As shown in Table 4, Indian players lack manufacturing units. Thus, India is increasingly focusing on electronics design, as seen by its sole focus on IC design houses, while the local leader Taiwan has involvement in a diversity of sub-sectors.

Table 4: Integrated Circuit Value Chain

Country	Design Houses	Mask Units	Chemical Vendors	Wafer Production Units	Fab Units	Susbstrate & Lead-Frame Vendors	Packaging Vendors	Testing Firms
Taiwan	260	4	19	8	13	19	36	34
India	125	-	-	-	Proposed 2007	-	1	-

Source: (Plan B Manufacturing, Ltd. 2007)

India still lacks in the production of high-tech, high-value items that require capital-intensive manufacturing, of which integrated circuits is the most significant. Normally surplus labor could be a draw for MNCs away from Taiwan and China to produce ICs in India, but the labor is not a big draw because so much of the chip production is now automated. Moreover, as the increased fixed costs of fabrication facilities, market volatility, and higher defect rates, have pushed state of the art fabrication facilities to a high cost of $3 billion (Semiconductor Industry Association 2008b), IC fabrication is left mostly in the hands of specialist firm's like Taiwan's TSMC. Although many of the licensing restrictions for firms in IC production have now been removed, India seems incapable of seriously encouraging either private firms or public firms to begin production of state-of-the-art ICs.

4.2. Finished Electronics Products

Currently within India the fastest growing sectors have been consumer electronics and telecommunications, which follow the historical trends within the industry. These firms are expected to account for 37 percent and 27 percent of the market in 2009, respectively (Carbone 2005). The telecommunications growth is mainly driven by India's leapfrogging past wired communications and into the consumption of wireless technologies. For consumer electronics, the growth has been driven mainly by Flat Screen TVs (FSTs), a follow on to Indian experience in black and white TV production, as well as color TV production. Other consumer electronics, such as microwave ovens, and audio equipment (i.e. radios and MP3 players) play an important role in the industry. The low penetration rate of these consumer durables among mid-income

families, as well as the indirect demand through products such as automobiles, is greatly responsible for these growth rates.

Within this significantly liberalized electronics market, there are roughly three categories of industry players, as shown in Figure 4. The production of finalized electronics products, in consumer electronics and telecommunications, is provided by Original Equipment Manufacturers (OEMs). Often an OEM contracts this work out to Original Design Manufacturers (ODMs), and Electronic Manufacturing Service Firms (EMS). The general difference between these ODMs and EMS firms is that the ODM firm also performs design work for the EMS firm. In some cases these ODMs fully design systems, and other times they work in tandem with the brand name firm to design and develop specifications for the product.

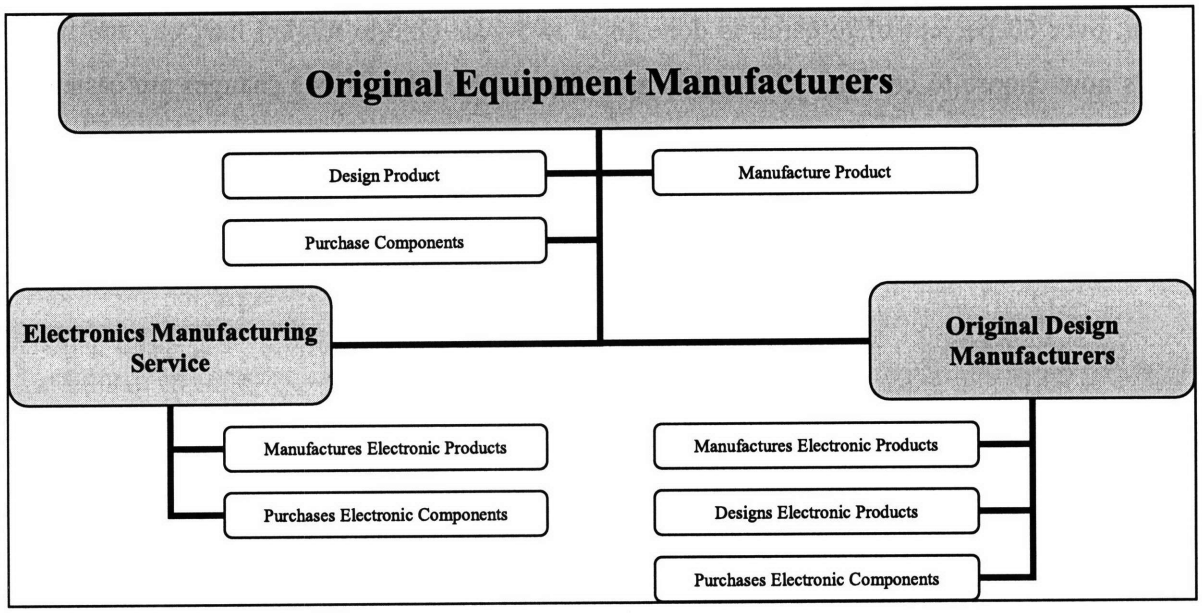

Figure 4: Electronics Manufacturing (Low Level)

Source: Author

Under liberalization, most of the OEMs and EMS firms in the Indian market have been foreign. Currently, 80 percent of the electronics manufacturing done in India is performed by multinational OEMs such as Nokia and Samsung, and multinational EMS providers such as Flextronics and Jabil. Before liberalization, much of this production was accomplished by local SSIs, even though production was not yet up to international standards of quality and price.

Worldwide, ODMs are currently the most profitable firms in the electronics industry, because they spend very little on R&D and capital. They typically specialize in only a few products, dedicating their resources to R&D in those products, and limiting their output to specific geographical areas. The EMS firms, on the other hand, specialize in a wider range of products, a wider range of services (i.e. assembly and logistics), and have a wider geographical output and clients. Thus, the EMS firms have required slightly higher capital costs, leading them to being the second most profitable firm-type worldwide. OEMs, which have experienced rising R&D costs in the development of new products, have had the lowest profitability ranking amongst the three (Plan B Manufacturing, Ltd. 2007).

The profitability rankings are important, because the current slow growth rate in the industry has led to profitability edging out growth as the key short-term goal across the industry. For this reason, over 60 percent of research is done for a two-year time-to market horizon, and many MNCs now choose to cut back on costs in areas like labor, where costs changes are easiest to effect (KPMG 2005).

5. Analysis

In the period before liberalization the capital-to-labor ratio, was higher than in the period directly after liberalization. Although in the late 1980s there was significantly more output per unit capital, this was after the start of the decade witnessed a significant decline in the output-to-capital ratio, shown in Figure 5. The capital-to-labor ratio was also higher in the late 1980s than in the 1970s. The output-to-capital ratio did not reach 1979 levels again until 1986, because there was a significant decline in this ratio after liberalization. Thus, the attributions that liberalization was an automatic and efficient aspect of the industry's development are specious.

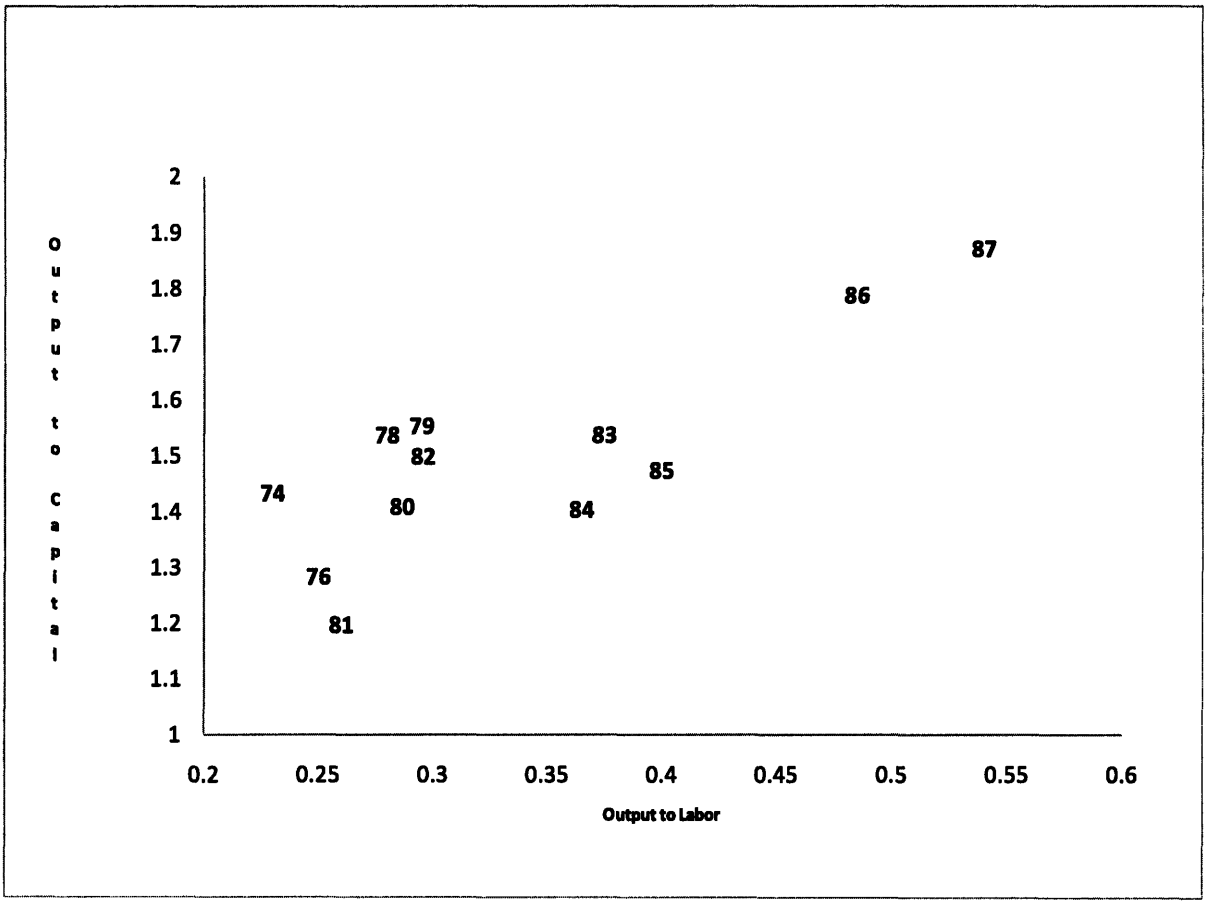

Figure 5: Labor and Capital Relationship in Industrial Output

Source: (Guhathakurta 1994)

The push to continue production in the post-liberalization period occurred foremost for those products and sub-sectors for which there was an explicit policy issue. The result was a growing imbalance in production, with growth occurring mainly in: TVs for consumer electronics, computers for professional electronics, and passive components and electromechanical components for the components sub-sector. A breakdown of this inter-sectoral imbalance is also shown in Table 5.

Table 5: Annual Average Rate of Growth and Share in Production of Different Sub-Sectors

Product Groups	1975-1980 (% Share)	1981-1987 (% Share)
Consumer Electronics	**20.4 (26.5)**	**39.6 (38.7)**
Radio Receivers	18.2 (20.0)	7.8 (14.1)
Television Receivers	28 (33.0)	56.2 (19.9)
Others	17.6 (21.0)	35.8 (45.6)
Professional Electronics	**15.1 (53.4)**	**30.9 (34.1)**
Communication	13.7 (44.1)	28.9 (14.8)
Defense	6.8 (19.7)	27.7 (14.8)
CI and IE	26.6 (29.2)	53.5 (17.3)
Computers	9.7 (7.0)	53.5 (33.8)
Components	**16.9 (20.1)**	**26.2 (17.3)**
Electron Tubes	13.7 (11.4)	42.1 (15.7)
Semiconductor	12.9 (17.8)	19.3 (15.0)
Devices		
Passive Components	21.0 (39.2)	21.1 (13.2)
Electromechanical	16.5 (30.0)	29.6 (32.1)
Components		

Source: (Tiwari 1993)

After liberalization, it was the consumer electronics and professional electronics sectors that experienced the greatest rise in the number of firms, as shown in Table 6.

Table 6: Number of Firms in Production

Product	1981	1983	1987
Television (B and W)	86	182	173
Colored	3	76	133
Computers	8	31	118
Printed Circuit Boards	32	87	91
Passives	48	71	75

Source: (Tiwari 1993)

However, only the television industry significantly increased its four firm concentration ratio, as shown in Table 7. This four firm concentration ratio increased from 31% to 42% between 1981 and 1987, despite there being a doubling in the number of firms.

Table 7: Changes in Four Firm Concentration Ratio

Product	1981 (%)	1983 (%)	1987 (%)
Television (B and W)	32	29	42
Colored		34	33
Computers	90	43	52
Printed Circuit Boards	83	50	54
Passives	53	58	59

Source: (Tiwari 1993)

Meanwhile, the small-scale firms held a miniscule 28 percent of production in 1991, although this is not much different from the period of 1981, as shown in Table 8. There was a great growth between 1981 and 1991, in the share of the sector that the organized private sector held. There was also great growth between 1991 and 2002, in the share of the sector that the small scale sector held, despite regulatory changes that no longer favored either of these firms. Although this growth in the small scale sector may be attributed to policies enacted after 1991, it is interesting to note the small scale sector also enjoyed a 38 percent share of the total production in 1988, long before 2002 when it again reached this level (Department of Information Technology, Data Bank & Information Division 1993).

Table 8: Growth and Production of Electronics - Sectorwise

Sector	Production (1981)		Production (1991)		Production (2002)	
	Value (Rs. Crore)	Share	Value (Rs. Crore)	Share	Value (Rs. Crore)	Share
Public	345	40.4	2935	29.4	5840	15.9
Organized Private	265	30.9	4000	41.5	17010	46.2
Small Scale	245	28.7	2720	28.1	13950	37.9

Source: (Department of Information Technology, Data Bank & Information Division 2003)

In Table 9, there is significant growth in electronic consumer goods after liberalization, but a significant decline in the growth rate for electronic capital goods. Much of this is due to the liberalization taking place beginning in 1980; however, this was more a result of devaluations in the currency. These devaluations in currency could not last permanently, and so the eventual effect of this premature liberalization can be seen in all sectors through the period 1988-1993.

Table 9: Trend Growth Rates in Electronics Output Across Different Product Groups

Year	Electronic Consumer Goods	Electronic Capital Goods	Electronic Intermediates
1971-1980	10.69	39.66	10.18
1980-1988	32.35	26.16	23.44
1988-1993	0.44	14.96	8.67
1993-1998	16.48	9.79	11.60

Source: (Joseph 2004)

5.1. Role of Firm Size

The focus on SSIs early on in India's industrial policy was detrimental to the production of high-tech capital intensive goods. Small scale firms indirectly aided foreign firms of high tech capital intensive products more than local firms, because they found importing knock-down kits more

profitable than sourcing locally. The heavy reliance on import kits effectively limited the demand for new and high quality ICs to be produced locally. Although, India had established the foreign collaborations to advance know-how for ICs, as in the BEL – RCA collaboration to produce high quality electronic intermediates, there was low demand for it because the small-scale consumer goods companies found it most beneficial to import knock down kits.

The Center for Strategic and Industrial Research (CSIR), which operated a series of government-owned electronics labs, illustrates a failure to ensure proper distribution of technical know-how. In the years leading up to liberalization, the three CSIR laboratories dedicated to electronics issued 148 licenses, only 9 went to large-scale firms, while roughly 93 percent were issued to the medium and small scale sectors that did not employ them to full use (Different 1978).

A further problem was the low amount of production for those production processes actually licensed, as shown in Table 10. A great deal of this was due to the three year time lag between licensing and deployment for the small-scale sector, which could not quickly update its production processes. Furthermore, of the processes used, only a small portion was considered useful for the purpose of production. It was only one production process, among the 131 developed by the three CSIR laboratories that accounted for 70 million rupees of the 90 million rupees in revenues. Another 3 process accounted for 15 million of the remaining 20 million rupees (Different 1978).

Table 10: Analysis of the Processes

Laboratory	Processes (since inception)			Sponsored projects (since inception)
	Developed	Licensed	In production in 1975 (excluding sponsored)	
NPL	72	61	20	9
CEERI	36	24	9	14
CSIO	23	13	5	16

Source: (Different 1978)

Given the failure of the CSIR to coordinate the type of positive technological spillovers, such as seen in South Korea with ETRI or Taiwan's ITRI, most large scale firms have largely relied on in house R&D to develop capabilities. Large scale firms with access to in-house R&D appear not to heavily desire access to the guidance and support of the government run laboratories. This in-house research is not unique to India though, as developing countries across the board have increasingly seen large firms prefer to do high-level research in-house. What is unique to India's situation in the electronics industry is that these large firms did not appear to even want government aid to support in-house R&D. This highlights that perhaps CSIR was too bureaucratic, and not closely aligned with the needs of industry, being more of an inhibitor than a helper. The dominance of in-house R&D in the era before liberalization is shown in Table 11.

Table 11: R&D in Indian Electronics

Organization	Estimated R&D Expenditure (Rs. Crore)		Estimated Production Based on Indigenous R&D (Rs. Crore)	
	1970	1975	1970	1975
All research institutions	200	350	N/A	N/A
Industrial R&D departments (large-scale sector)	60	150	150	750
Three CSIR laboratories	20	35	16	90

Source: (Different 1978)

Even as of the year 1996, roughly 3000 of the 3500 firms producing electronic devices were from the small scale sector. However, of these firms, only 300 accounted for 70 percent of production, and only 100 of these were from the small scale sector (Joseph 2004). The shift from small-sector oriented policies was rather late, part of the reason why electronic consumer goods are still characterized by a short-term outlook with fairly low levels of R&D. As shown in
Table 12, immediately after liberalization the small scale sector was most involved with electronic consumer goods when it was shown that large scale firms were more efficient. In the IC market, where most of the firms had been government controlled, there was not a significant shift in the market structure, showing that these large government-run firms, including BEL, were highly inefficient. The essential error of the Indian government was to make large scale

firms captive to inefficient small scale firms and the homogenous demand of government procurement. These large scale firms could not sell their components to small scale firms since most could not afford them. Additionally, many of the small scale firms became accustomed to using international components, due to their extensive copying of designs.

Table 12: Share of Small- and Large-Scale Sectors in Electronics Production

Product	1981		1992	
	Large Scale	Small Scale	Large Scale	Small Scale
Electronic consumer goods	34.0	66.0	50.0	50.0
Electronic capital goods	66.0	34.0	79.8	20.2
Electronic intermediates	67.0	33.0	78.2	21.8
Total	**66.0**	**34.0**	**71.7**	**12.8**

Source: (Benitah 2004)

From India's small scale establishment, a great number of firms have emerged, which are dedicated to electronics design. The top firms in this design sub-sector have experienced much higher gross margins than the EMS firms within India, as shown in Table 13. Because these are small firms, the total revenues of these firms and their contribution to GDP is very small.

Table 13: Top EMS and ODM Firms in India

EMS	Gross Margin %	Gross Margin %	ODM
Flextronics	6%	19%	**Asustek**
Jabil	8%	6%	**Quanta**
Solectron	5%	6%	**Compal**
Sanmina-SCL	5%	12%	**BenQ**
Celestica	5%	10%	**Lite-on**

Source: (Plan B Manufacturing Ltd. 2006)

India has greatly developed its ODM sector, attempting to leverage its design skills. These ODMs, however still achieve less total revenues than EMS firms, even though there is evidence

that their profit margins have been substantial. This continuance of small scale dominance is partly a failure of the Indian government to encourage economies of scale either through large scale firms, or better top-down coordination for the litany of small scale firms that have existed.

5.2. Role of Ownership

These public firms have been criticized for being inefficient portions of the electronics sector before liberalization. Even though liberalization is cited as a major reason for the decline of firms like ECIL, Table 14 shows that public firms' market shares were decreasing before the advent of liberalization, countering any suggestion that liberalization revealed its inefficiencies.

Table 14: Computer Market Structure of India (percentage of total market)

Company	1960-1966	1967-1972	1973-1977	1978-1980
ECIL (Public)	0	3.4	40.3	10.2
HCL(Private)	0	0	0	40.5
DCM (Private)	0	0	0	27.5
ORG (Private)	0	0	0	7.3
IBM (Foreign)	73.8	73.1	3.1	0
ICL (Private)	4.7	11.7	9.9	2.1
DEC (Public)	0	0.7	25.1	3.6
Honywell-CII (Foreign)	0	8.3	1.0	0.2

Source: (Dedrick and Kraemer 1993)

In Table 15, we see after the initial liberalization in 1981, a significant shift in production from the public sector to the private sectors. Also, within the electronic capital goods sector we see that there was a rise in state participation following liberalization, which signals the effect of proactive policies states engaged in to draw create local capital., but even more so a signal of the lateness in promoting electronic capital goods. Fundamentally though, the push of liberalization resulted in more large private firms participating in the manufacturing of electronic capital goods.

Table 15: Share of Public and Private Sectors in Electronics Production

Sector	1981			1992		
	Public Sector		Private Sector	Public Sector		Private Sector
	Central	*State*		*Central*	*State*	
Electronic consumer goods	3.6	5.3	91.1	3.1	1.9	95.0
Electronic capital goods	62.9	3.4	33.7	46.2	6.2	47.6
Electronic intermediates	23.7	5.2	71.1	12.1	4.6	83.3
Total	**37.2**	**4.3**	**58.5**	**26.5**	**4.5**	**69.0**

Source: (Benitah 2004)

Since liberalization, only 20 percent of OEMs and EMS firms operating within India are locally owned. Additionally, within India's electronics design subsector, most of the design is still performed by MNCs running captive design units, which now account for 70 percent of these design companies (Bindra 2005). In Bangalore, India's leading city for design services, 30 of the approximately 70 design firms are the captive units of MNCs. Most of these companies followed on the heels of Texas Instruments, which was the first company to begin design operations within India, opening a center in Bangalore in 1985. In fact, of the top twenty U.S. IC companies, all but two have located their design operations within India. (Brown and Linden 2006).

Although MNCs outsource or establish offshore subsidiaries, offering employment opportunities to Indian workers, a foremost concern is that these MNCs have not traditionally outsourced the most value added aspects of IC design: the front-end aspects, which include the initial specifications, functional requirements, and system level architecture. A recent survey of industry executives, demonstrated the low percentage of companies outsourcing front end design, as shown in Figure 6. This trend extends well into India's electronics industry. Most of the high-level research done in high-tech areas (i.e. electronics) is now performed by or with the support of government, even as there is much scholarly opposition to government involvement.

Most of the overall expenditures are now in areas of design; however, the private sector now accounts for less than 15 percent of the R&D expenditures in India (Joseph 2004).

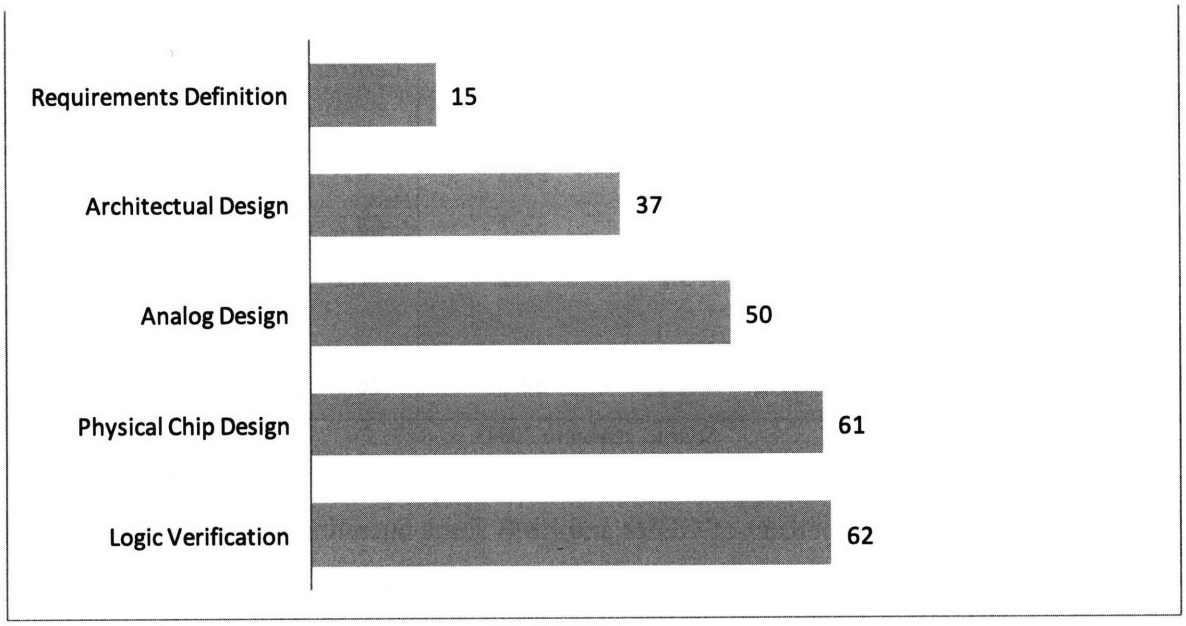

Figure 6: Outsourcing Chip Design

Source: (EE Times 2005)

This lack of front-end design is crucial, as the front-end process of establishing specifications, has experienced an over 10-fold increase in man hours required over the last decade (Leachman and Leachman 2004). The pure manufacturing processes, although labor intensive, has been found to constitute only a small component of total costs. For instance, in Taiwan and China, the labor costs average only 8 percent and 3 percent respectively (Brown et al. 2005).

The research being performed has historically been greatest in Indian research institutions. These institutions have been most closely aligned to industry, or more specific problems, as they are directly under certain departments: such as the Department of Atomic Energy or the Ministry of Defense. Aside from those institutions, the five dominant large scale units (both public and private) accomplished high levels of R&D as well as high levels of R&D efficiency as determined by the ratio of their production revenues to their R&D expenditures. The three CSIR laboratories did not prove to be heavily effective in either R&D expenditures or production arising from those expenditures (Joseph 2004). .

Also, historically within Indian industry, joint ventures have spent proportionally more on R&D than Indian-owned enterprises, and those firms that licensed technology performed more R&D than those who did not. This shows that perhaps India was misguided in their complete refusal to allow foreign collaboration. It appears that the joint ventures and licensed technology that allowed technology transfer did not replace domestic R&D, but instead stimulated its growth (Chee-Wah 2006).

5.3. Role of Outward Orientation

Regarding exports, it can be seen in Table 16, that in the period after liberalization most of the export growth has been in consumer electronics, possibly fueled by more electronics capital goods remaining within India.

Table 16: Trends in Electronics Exports by Major Product Group (Compound Growth Rate)

Year	Electronic Consumer Goods	Electronic Capital Goods	Electronic Intermediates	Software
1981-1988	11.85	45.35	21.62	40.08
1988-1994	20.35	6.81	-2.09	32.78

Source: (Joseph 2004)

India has recently tried to promote heavy exports of electronics through its use of Special Economic Zones (SEZs). Yet, while there are roughly 20 SEZs, exports have gone from only 8 of these (National Portal of India: Commerce and Industries 2008). Generally, exporters have been small and medium enterprises within these zones, providing low investment in capital intensive activities, low-value added and low employment. Scholars have suggested that a major reason for this low-investment level within SEZs is that financial incentives are less of a draw than is proper infrastructure and available land: something seen in China's SEZs but not India's(2007). As such, incentives within these zones gave priority to simply minimizing imports, rather than developing a strong domestic capability to supplant the firms that India imported from.

While exports have not been heavily produced as a result of these SEZs, with the exception of products assembled through kits, imports have in fact risen with the use of these SEZs. This is also fueled by India's relaxation of import duties within these zones. More important perhaps is India's involvement in World Trade Organization (WTO) Agreements, whose mandates for local taxes have had a perverse effect on exports stemming from these zones. As shown in Table 17, India has no duties on imports, but has imposed local taxes on component production, making it even more advantageous for firms to import. Given this, India has found it continuously easy to import items as knock-down kits, or simply to import components for assembly, before exporting.

Table 17: WTO Electronics Design

Duties	Components	Selected Finished Goods
Import	0%	0%
Local Excise Tax (on manufactured items)	16%	0%
*Computers, Set Top Boxes, and Cell Phones		

Source: *(Plan B Manufacturing Ltd. 2006)*

India's initial policy of promoting indigenization through import substitution greatly contributed to the buildup of local skills in this sector. However, it greatly limited the quality of production. The premature liberalization and attempted export-led growth let these Indian firms keep up-to-date, but it did so with an extreme use of import kits in the face of attempted SSI promotion. The was a diminishing of skills and R&D within the Indian electronics sector, as opposed to the theories that export-led growth would lead to increased R&D intensity.

This export driven strategy appears to have left the economy without many linkages in either the forward or backwards direction. Furthermore, the money earned from this approach does not necessarily influence the economy in the way often stated. It increased international demand, but products that weren't exported, such as those within the components and capital goods sectors, have experienced price increases as a result of being in lower demand. Paradoxically, this rise in prices has lead to the opposite of what the transaction costs economists desire, a decline in the

intensity of competition. The increased firm concentration in areas like components has occurred not because these large, mostly public firms were too concentrated to supply quality products, but because the lack of demand forced these sectors to have even greater concentration.

Additionally, while liberalization is credited with heavily promoting software exports, these software exports have doubled every three years since the 1980s, well before the industry wide liberalization that took place. For those that suggest liberalization should have occurred earlier to promote foreign exchange, they ignore that remittances from NRIs (mostly software engineers) have been valued at more than three times whatever foreign exchange that has been garnered from software exports (Joseph 2002), while the domestic industry was able to maintain stability and allow workers to gain skills abroad.

The protection of the industry before liberalization limited the software industry by disallowing it necessary tools for software development. In addition to hurting software production from the supply-side, low computer hardware penetration has limited the demand for software within the country. For these reasons, it has often proved better to send software workers abroad to perform work and gain experience. As of 1990, 70 percent of India's software exports were achieved in this manner, where programmers were sent abroad to a foreign client on a contract basis (Dedrick and Kraemer 1993). As shown in Figure 7, the software industry got its biggest boom in exports when exports commencing from the SEEPZ were stable and software exports outpaced computer exports.

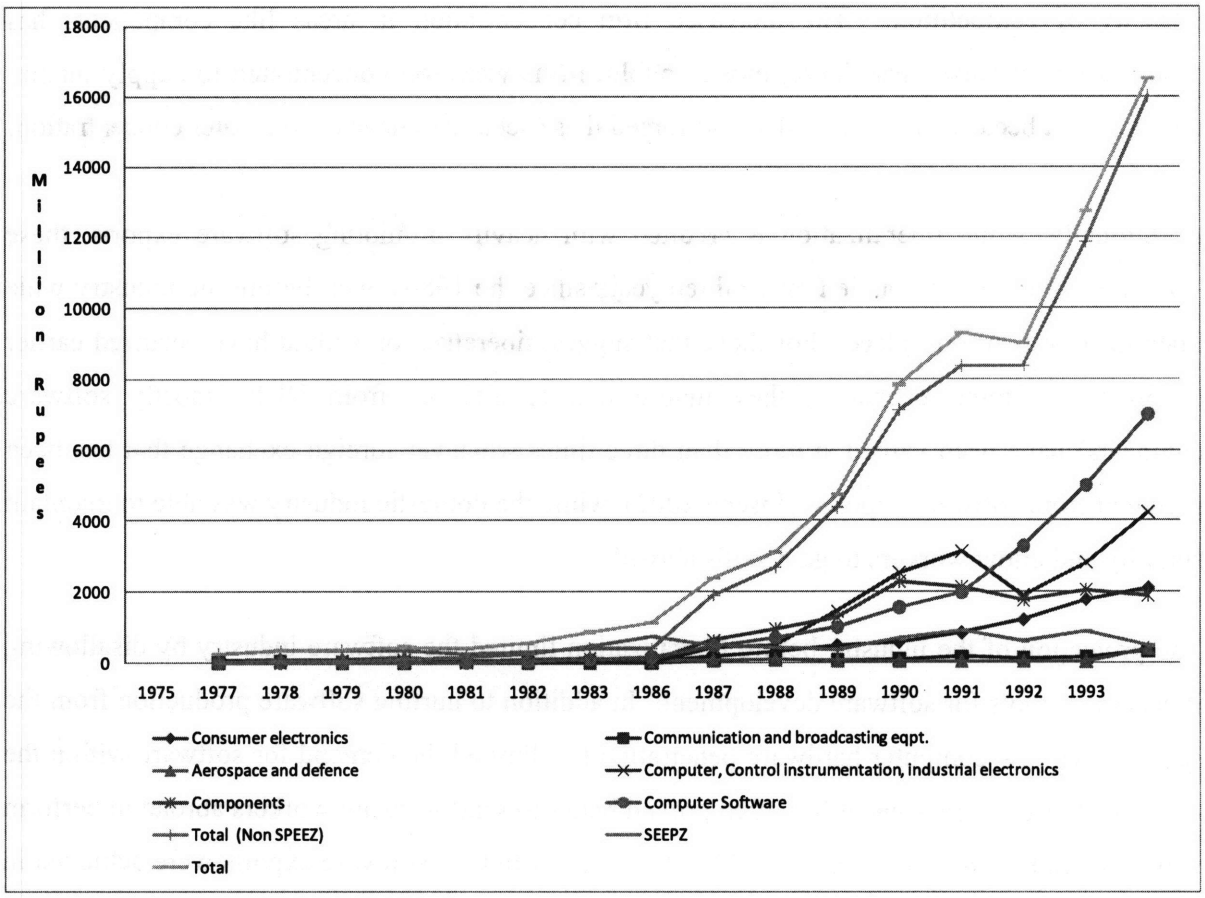

Figure 7: Electronics Exports

Source: (Department of Information Technology, Data Bank & Information Division 1993)

As shown in Table 18, the growth in computer sales after liberalization was only a temporary change.

Table 18: Sales of Indian Computers

Year	Sales (US$ Millions)	Growth from Previous Period (%)
1979-1980	12	N/A
1981-1982	52	333
1983-1984	96	85
1985-1986	180	88
1987-1988	370	105
1988-1989	560	51
1989-1990	930	66

Source: (Dedrick and Kraemer 1993).

5.4. Performance

5.4.1. Foreign Collaborations

During the period of the 1970s, the major imports originated in the telecommunications and defense equipment areas, as well as the space programs, atomic energy programs, and instrumentation sub-sector. Even so, at the time there were several restrictions on the import of consumer electronic items, including radios, TV sets, tape recorders, music systems, and video recorders. The import duties on computers in the 1970s were up to 200 percent for components, and 30 percent excise duties on the finished products. For those companies that were actually manufacturing within India, most of the manufacturing was actually refurbishment rather than manufacturing of new products (Agarwal 1985).

In the years after liberalization there was a significant increase in the imports of components, as well as foreign collaborations and R&D. However, the increased imports and export-led growth were not the reason for the increased R&D expenditures, as is suggested under neoliberal ideas; rather the increase in R&D expenditure was more the result of the drastic fall in R&D expenditures before liberalization, as shown in Table 19.

Table 19: Data for Imports, R&D, and Foreign Collaborations

Year	Effective Rate of Protection	Imports of Components (thousand rupees)	R&D expenditure (thousand rupees)	Foreign Collaborations
1978		3,615	94	5
1979		8,100	90	6
1980	-0.2	11,185	75	7
1981	2.3	9,776	60	7
1982	9.8	12,239	61	9
1983	17.1	17,654	57	11
1984	19.5	16,475	45	17
1985	16.0	14,427	87	34
1986	16.1	20,633	120	68

Source: (Tiwari 1993)

Additionally, the attempts at foreign technology transfer were not very successful. In the development of the electronics sector, the low-level of foreign technology transfer significantly inhibited the firm. In seeking to establish positive balances of payments, and prevent foreign firms from domination, it was ignored that foreign firms and foreign collaborations would help with the issue of foreign exchanges. Also it was ignored that when properly structured these relationships could significantly advance technological know-how.

For the little successful foreign collaboration that did take place, India got access to new technology only at the beginning of the collaboration. The lack of performance standards for these collaborations, as well as royalty payment restrictions discouraged foreigners from revealing the secrets of new technology, inhibiting the success of some Indian firms. The result of this protection was a growth in the domestic industry, but also a great amount of products available at low quality but high cost. Although India had developed significant design skills by this time, as indicated by BEL's design of its first chip in concert with the Tata Institute of Fundamental Research in 1971, the lack of foreign collaboration prevented the development of the production know-how that would make this design feasible. At this point, the lack of collaboration and extensive copying of foreign designs severely damaged any standardization

there may have been throughout the industry. As a result, the reliance on imports and import-kits was further aggravated.

5.4.2. Domestic vs. International Standards

In the years before significant liberalization, there was a significant rise in the price-performance gap, allowing it to appear that this liberalization had a significant effect in narrowing this gap. During this period, India began its switch to international standards, presaging its export-led growth before export-led growth actually occurred. This switch to international standards in producing micro- and some minicomputer components left Indian manufacturers at a temporarily weaker position. Figure 8 shows the trends in this price-performance gap, compared to the United States (the leader in the industry).

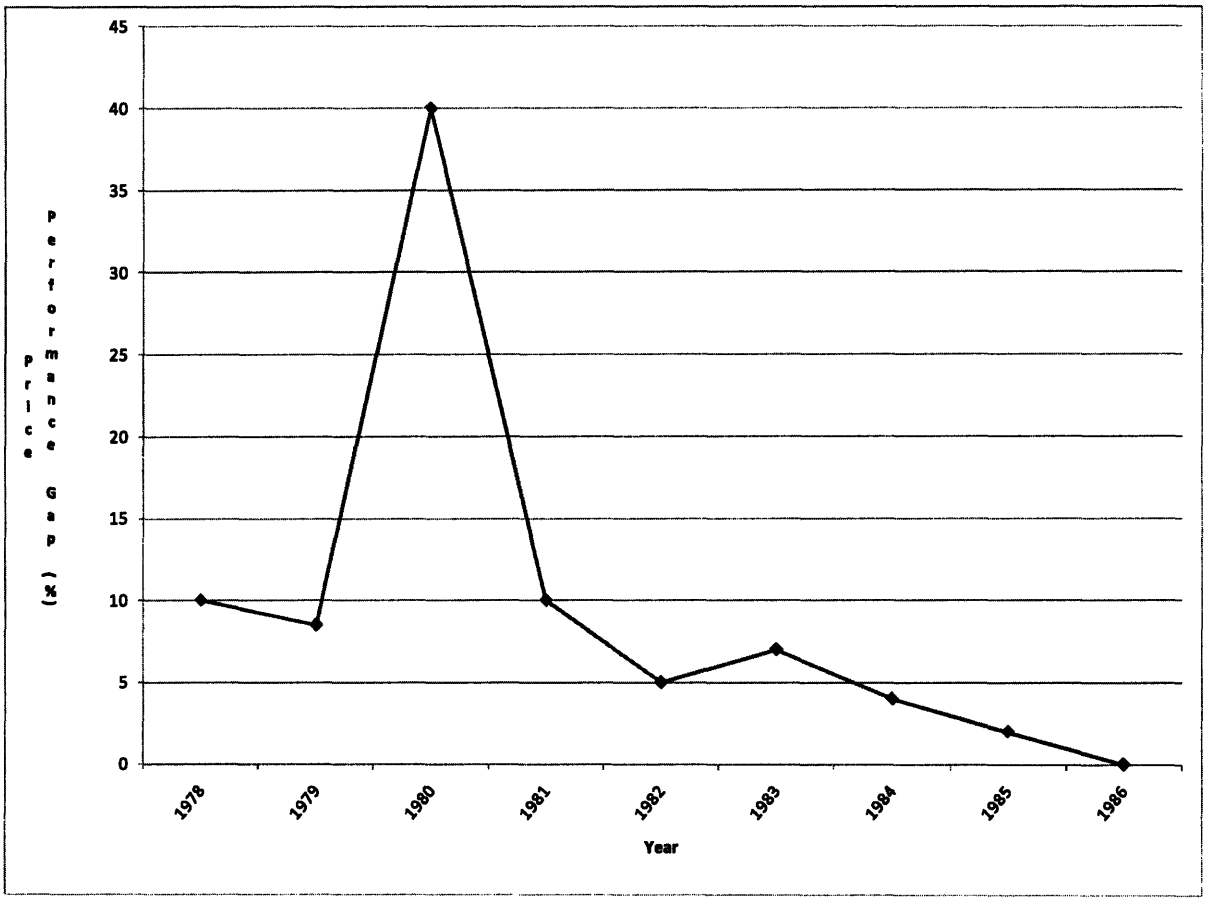

Figure 8: Price-Performance Gap in Indian Electronics Industry

Source: (Brunner 1991)

Along with this switch toward international standards was the gradual relaxation of the licensing rules. With this, though, there were several interesting things that occurred: the number of foreign collaborations increased, the effective rate of protection increased, and the level of R&D expenditure decreased (Tiwari 1993). Since the government required domestic private computer firms to spend at least 2% of total annual turnover on R&D it can be concluded that either the large number of firms had too thin of profit margins to do research alone or coordinate research efforts, or the large number of foreign firms were not doing high-levels of domestic R&D.

5.4.3. Import-Content

After liberalization, the steady trend of imports as a share of production rose dramatically, only returning to the import-content level of 1975 by 1987, as shown in Figure 9.

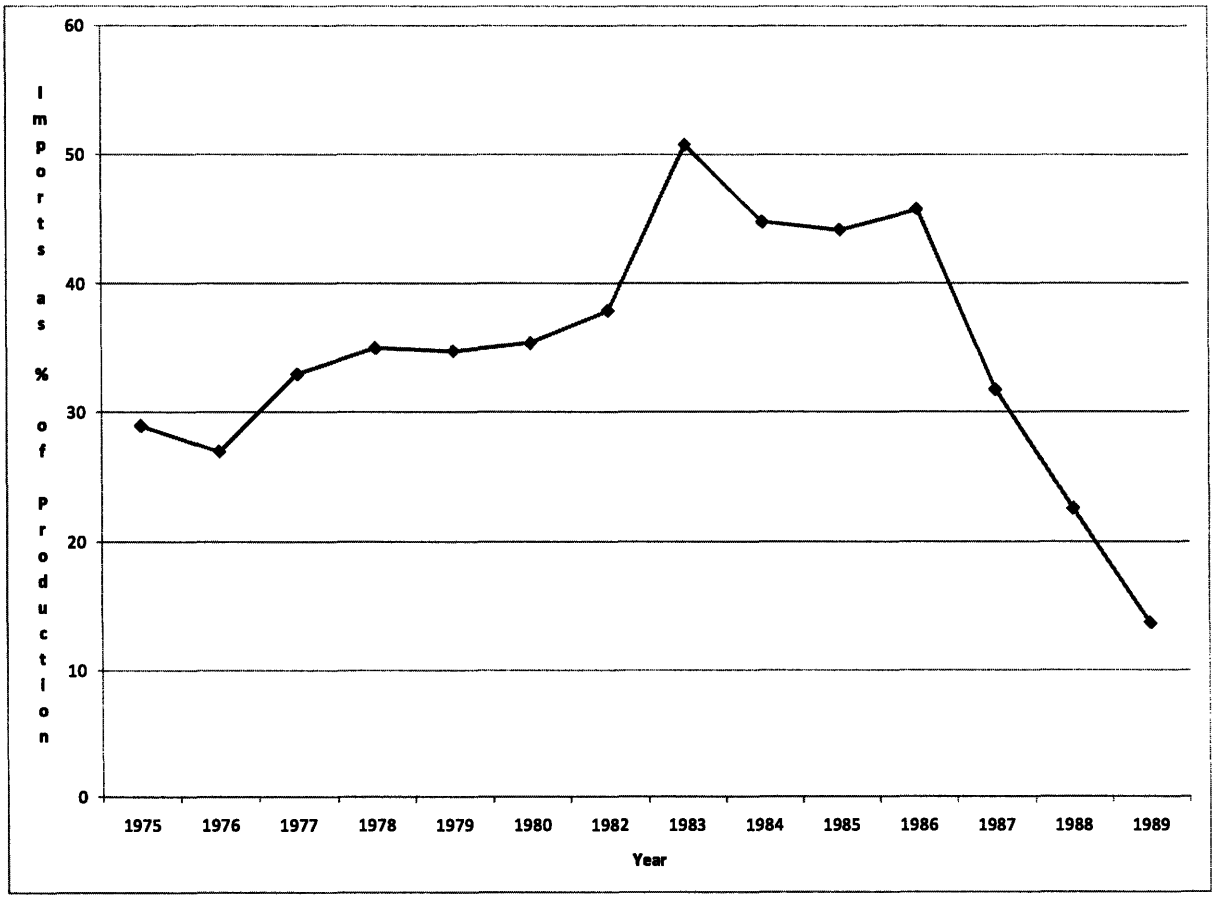

Figure 9: Imports as a Percentage of Total Production

Source: (Tiwari 1993)

The gap between production of components and the demand of components would continue to increase as a result of the widespread use of import kits. As shown in Table 20, the demand supply gap increased steadily throughout the 1980s, during the process of liberalization.

Table 20: Demand and Supply Gap of Electronic Components

Year	Equipment Production (A)	Component Demand (B)	Component Production (C)	Demand-Supply Gap (B-C)	Gap as Percent of Demand (B – C) / B
1980	5,950	2,070	1,600	470	23.7
1981	7,160	2,910	1,800	1,110	38.1
1982	9,970	3,490	2,230	1,260	36.1
1983	11,480	4,020	2,700	1,320	32.8
1984	16,400	5,850	3,200	2,650	45.3
1985	23,250	8,700	4,400	4,300	49.4
1986	31,000	11,250	5,500	5,750	51.1
1987	43,140	16,100	7,750	8,350	51.9
1988	56,300	20,950	11,250	9,700	46.3
1989	72,500	26,800	16,000	10,800	40.3
Compound Annual Growth Rate (%)	**30**	**31**	**28**	**38**	

Source: (Guhathakurta 1994)

The initial reason for the rise in import-content was a slow growth rate in production. The sectoral trends show that the low average growth rate was largely due to slower growth in the components sector, which from 1975-1980 significantly lagged both consumer electronics and professional electronics. Both consumer electronics and professional electronics would be liberalized at later dates than components. The reemergence of the electronics sector had more to do with the timing of liberalization in these other sectors than with the liberalization of electronic components.

In fact, the component industry has largely followed the growth and trends of the consumer electronics industry. In the 1960s, most of the components were for radio receivers. In the early 1970s they were for black and white TV receivers, and in the late 1970s components were produced for tape recorders. In the 1990s much of the components were dedicated toward the telecommunications sector and color TVs. Currently, 60 percent of local component production is accounted for by the television industry. Another 30 percent is accounted for by the telecommunications and industrial sectors. (Department of Information Technology, Data Bank & Information Division 2003)

Components which experienced less dramatic changes in the four firm concentration ratio, and the number of firms in production, were lead by the public sector enterprises of BEL and ECIL. Unlike many of the private firms, BEL and ECIL used a significant degree of locally produced components in their products. Table 21 shows more details on the import-content of firms after the period of initial liberalization. It shows that the public sector firms – mainly BEL – have paved the way in having high value added through low import-content. However, private sector firms like HTL, ITL, and ET&T, had grown to achieve much of the production, with ITL being the only firm with low import-content.

Table 21: Top Firms and Import-Content of Electronics Products

Enterprise (public or private)	1985-1986				1986-1987				1987-1988			
	A	B	C	D	A	B	C	D	A	B	C	D
BEL (public)		796	21,870	3.6	977	2,252	29.881	10.8	2,430	2,504	38,051	13.0
CEL (private)			561			612	1311	46.7		853	1,660	51.4
ECIL (public)	953	6,065	12,822	54.7	3102	6020	16838	54.2	2516	6233	18562	47.1
ET & T (private)	11,546	738	12,457	98.6	7,803	2,043	10,511	93.7	8,760	3,254	12,192	98.5
HTL (private)			1,186		634		1,904	33.3	641		1,926	33.3
ITL (private)	2,912		29,953	9.7	9,709		44,070	22.0	13,040		51,023	25.6
SCL (public)	180	425	785	77.1	342	477	880	93.1	661	346	1,201	83.4
Total	15,591	8,024	79,634	29.7	22,567	11,404	105,395	32.2	28,048	13,190	124,615	33.1

A: Where import content is 75 percent of bill of material

B: Where import content is 50 percent to 75 percent of bill of material

C: Total Turnover

D: Percent of (A+B) to C

Source: (Tiwari 1993)

Although ICs were only a small part of total costs, these other firms did not want to modify the design of their finished products to match the new IC designs. Producing newly designed products would dramatically raise costs. Even in fast growing sectors like telecommunications, the low level of demand has been below the threshold for efficient production. Thus, Indian prices would end up being at least 20 percent greater than international prices, and of lower quality. Since they were only producing to meet a small demand, their bulk orders for components were relatively small compared to many foreign firms. Thus, many small Indian firms faced prices for components that were at least 15 percent above their world competitors' price, pushing up the costs of their final products (Wellenius et al. 1993).

5.4.3. Employment and Wages

Employment generation within the electronics industry has typically been higher than in other industries. In the years before liberalization, employment in electronics was at twice the rate of the textiles industry, and ten times that of the chemical industry (Department of Information Technology, Data Bank & Information Division 2003) (Joseph 2004) . During this time period there was a heavy promotion of SSIs to achieve spatial dispersion of employment, which appeared possible given that electronics is not highly location-specific.

Now, as shown in Table 22, the amount of labor in the electronics industry has declined dramatically since liberalization, seemingly because of the heavy promotion of SSIs and FDI. The measures of labor-to-capital (L/K) and labor-to-output (L/O) both show a dramatic decline. Where electronics was once ranked fourth in employment within India, it is now near the bottom in its ranking.

Table 22: Employment Generation Capability of Electronics vis-a-vis Other Industries

Product	1976-1977		1995-1996	
	L/K	L/O	L/K	L/O
Electronics	2.65	2.46	0.29	0.06

Source: (Joseph 2004)

The rate of employment change was not significantly different after 1981, compared to before 1981. This growth rate in the number of workers is shown in Table 23 (Guhathakurta 1994). Though this information seems to imply that the growth of the industry was fueled by new entrants rather than productivity increases, the increased share of the market captured by fewer firms suggests otherwise. The small-scale sector with its many entrants may have achieved overall increases in market share, but that a few large scale firms grew to take even more significant aspects of the industry, the primary reason for the advances in productivity.

Table 23: Annual Rate of Change in Capital and Labor Inputs Before and After Liberalization

Variables	Growth Rates	
	1973 to 1980 (%)	1980 to 1987 (%)
Factories	9.3	8.6
Fixed Capital	8.8	15.3
Working Capital	9.0	12.6
Fixed Capital/Factory	-0.5	6.2
Workers	4.1	3.8
Workers/Factory	-4.8	-4.5
Capital/Labor Ratio	3.5	10.4

Source: (Guhathakurta 1994)

As shown in Table 24, the total industrial output has increased significantly. However, even though the years of 1980-1987 had significantly higher output and net value added than the previous seven years, the growth rates in wages per worker have decreased significantly.

Table 24: Economic Indicators for Industry

Economic Indicators	Growth Rates	
	1973 to 1980 (%)	1980 to 1987(%)
Gross output per factory	5%	8.3%
Net value added per factory	-2.6%	4.9%
Total value added industry wide	6.5%	13.9%
Total output industry wide	9.9%	17.7%
Value Added per employee	1.3%	9.1%
Total output per employee	4.5%	12.7%
Wages per worker	4.1%	1.5%

Source: (Guhathakurta 1994)

Within India, the public sector still employs the most persons, with approximately 24 percent of the total employment as of 2002, as shown in Table 25.

Table 25: Manpower Employed in Electronics Equipment and Components Sector

Company Type	1981 (% Share)	1991 (% Share)	2002 (% Share)
Public Sector	**(55%)**	**(35%)**	**(24%)**
Central Public	67,000 (52%)	83,000 (29%)	77,000 (22%)
State Public	4,500 (3%)	18,000 (6%)	17,000 (2%)
Organized Private Sector	**27,500 (21%)**	**65,000 (22%)**	**123,000 (32%)**
Small Scale Sector	**31,000 (24%)**	**124,000 (43%)**	**173,000 (44%)**
Total	**130,000**	**290,000**	**390,000**

Source: (Department of Information Technology, Data Bank & Information Division 1993); (Department of Information Technology, Data Bank & Information Division 2003)

The organized private sector has been the driver though, with 32 percent of the employment and 46 percent of the production (Department of Information Technology, Data Bank & Information Division 2003). The more indirect employment is shown in Table 26.

Table 26: Employment in Electronics (Indirect Employment included)

Company Type	1981 (% Share)	1991 (% Share)	2002 (% Share)
Public Sector	**(44%)**	**(39%)**	**(29%)**
Central Public	46,000 (15%)	311,000 (24%)	720,000 (23%)
State Public	87,000 (29%)	196,000 (15%)	180,000 (6%)
Organized Private Sector	**88,000 (29%)**	**572,000 (44%)**	**1,400,000 (44%)**
Small Scale Sector	**79,000 (26%)**	**235,000 (18%)**	**850,000 (27%)**
Total	**300,000**	**1,314,000**	**3,150,000**

Source: (Department of Information Technology, Data Bank & Information Division 1993); (Department of Information Technology, Data Bank & Information Division 2003)

5.4.4. Variations amongst States

The states have all maintained different focuses within the industry, and they have significantly different degrees in employment. For instance, Delhi has historically had a significant share of small scale firms dedicated to the consumer electronics and computer market. Karnataka, Maharashtra, and Uttar Pradesh have focused primarily on components production. Meanwhile, Maharashtra and Dehli have also focused on consumer electronics with larger firms. Karnataka and Uttar Pradesh have focused on the development of professional electronics equipment.

Components and professional equipment have been more effective in lower per capita production areas, even though these places have the highest unemployment levels. Consumer electronics may be more effectively produced in higher production per capita areas. In almost every state the level of employment after liberalization is heavily outpacing production capabilities, as shown in Figure 10.

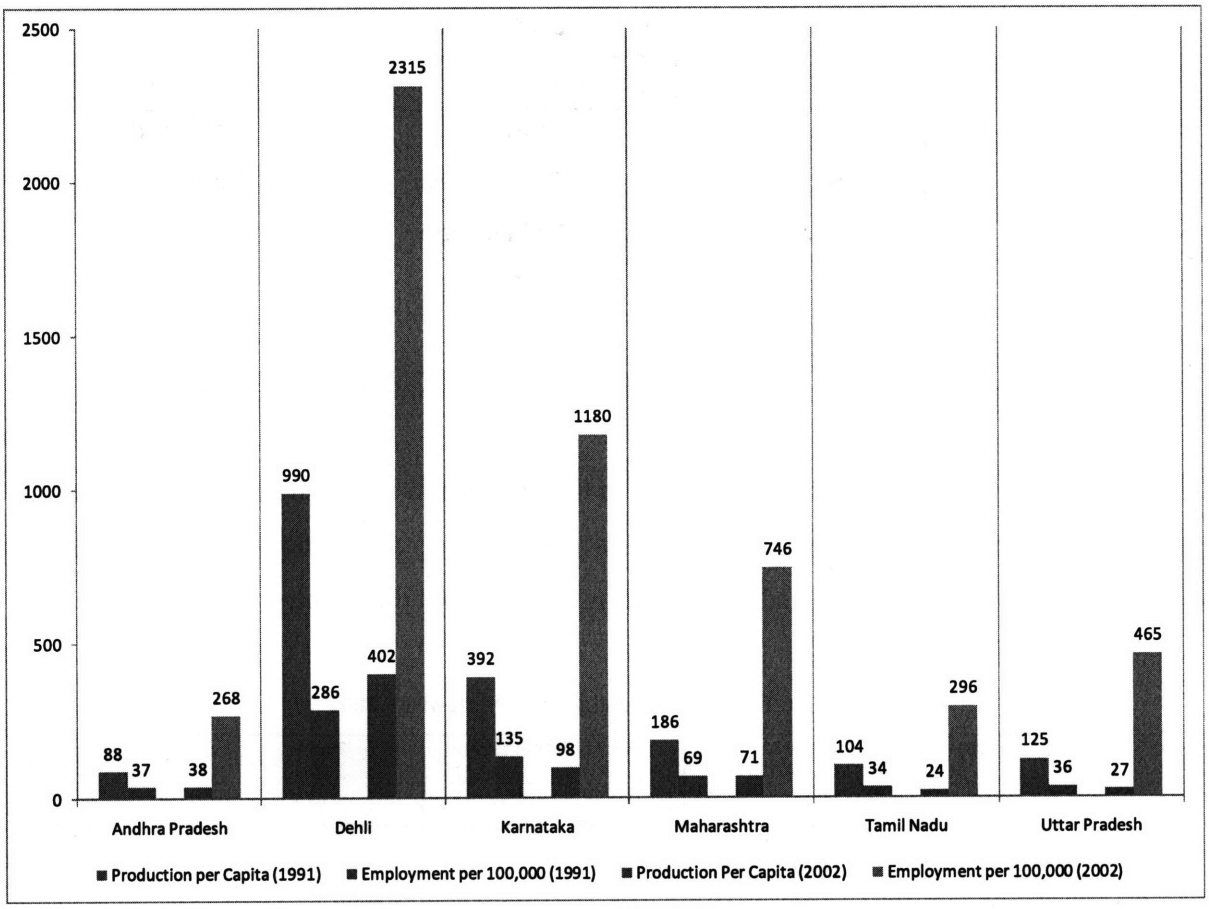

Figure 10: Statewise Production and Employment

Source: (Department of Information Technology, Data Bank & Information Division 2003)

The focus of the different states within India's electronics industry has varied greatly. As of 1971, the majority of the activity had occurred in three states: Bangalore, Bombay/Pune, and Delhi. In Bangalore, there were major public sector corporations in defense and telecommunications. In Bombay and Pune, there were many private sector firms, which had been the large foreign owned firms, established early on in the industry's existence. In Delhi, a vibrant SSI industry sprang up for making radios, components for radio and, later, black and white TVs (Department of Information Technology, Data Bank & Information Division 2003). More recently, other states have arisen to come to the forefront of this industry within India, as shown in Table 27.

Table 27: Major Producing States of Electronics in India

Rank	1981	1992	2002
1	Maharashtra	Karnataka	Uttar Pradesh
2	Karnataka	Uttar Pradesh	Maharashtra
3	Delhi	Maharashtra	Karnataka
4	Uttar Pradesh	Delhi	Delhi
5	Andhra Pradesh	Tamil Nadu	Andhra Pradesh

Source: (Department of Information Technology, Data Bank & Information Division 2003), (Ramakrishna 1986)

A more precise illustration of the recent trends in these top states is shown in Table 28. The state governments have set up numerous electronics development corporations to ensure that the electronics industry developed in a balanced manner throughout the country.

Table 28: Electronics Production - Statewise - 2002

State	1981		1991		No. of Units in 1991			2002		No. of Units in 2002		
	Production (Rs. Crores)	% Share	Production (Rs. Crores)	% Share	Total	SSI	Employment	Production (Rs. Crores)	% Share	Total	SSI	Employment
Andhra Pradesh	61	7.34	585	6.02	144	106	26,000	2030	5.52	169	132	28000
Dehli	121	14.61	921	9.47	312	266	38,600	3190	8.67	354	330	39500
Karnataka	173	20.71	1750	18.00	276	212	46,000	6232	16.93	363	289	71000
Maharashtra	198	23.77	1762	18.12	711	609	58,000	7219	19.62	809	693	67000
Tamil Nadu	34	4.06	622	6.39	273	215	16,400	1839	5.00	278	220	21000
Uttar Pradesh	91	10.98	1915	19.69	181	107	40,950	7715	20.96	170	115	59300

Source: (Department of Information Technology, Data Bank & Information Division 1993); (Department of Information Technology, Data Bank & Information Division 2003)

The sectoral breakdown for these top states as of 2002 is given in Table 29. It shows that the most recent leader Uttar Pradesh focuses primarily on consumer electronics. It also shows that those firms heavily involved in consumer electronics now, are also heavily involved in component production. In comparing Uttar Pradesh to the second leader of Tamil Nadu, it is shown that high levels of employment can be achieved along with the high levels of efficiency and concentration in large firms. Both Maharashtra and Uttar Pradesh are predominately involved in the consumer electronics sub-sector. However, Maharashtra has grown from having

711 production units in 1991 to 809 production units in 2002, while Uttar Pradesh has gone from having 181 units in 1991 to 170 units in 2002. The implication is that Uttar Pradesh maintains several large units that are much more efficient, as it has emerged from the fourth ranked electronics state immediately after liberalization, to the first rank in 2002. Still, when compared to Maharashtra, which was ranked second in 2002, the employment level is almost equally substantial.

Table 29: Electronics Production - Statewise - 2002

State	Consumer	CIIE	Computer	Telecom	Strategic	Component	Total
Andhra Pradesh	265	505	150	270	660	180	2030
Dehli	1410	200	350	75	5	1150	3190
Karnataka	950	1830	350	800	1062	1240	6232
Maharashtra	3680	1055	1360	185	74	865	7219
Tamil Nadu	950	310	145	177	37	220	1839
Uttar Pradesh	4230	400	550	1130	295	1110	7715

Source: (Department of Information Technology, Data Bank & Information Division 2003)

6. Conclusions and Recommendations

6.1. Conclusions

India's strategy for development has been less effective, because it has not been as nuanced in each strategy as Taiwan, and has employed contradictory policies to a degree that China has not. In its first stage of development India participated directly in production, and has been heavily against FDI. However, when seeking to transfer many capabilities to the private sector, India has failed less because of its discouragement in FDI, and more because it limited economies of scale through its anti-trust position without promoting the kind of human resource strategies that would encourage greater cooperation amongst the smaller firms found in the Indian electronics industry.

Even in its abundance, the partly skilled labor within India has not been a huge draw. This is partly because of the decreasing role that labor played within the assembly marketplace, which moved toward greater automation in the 1980s. India, jumped into this arena too late, given that outsourcing and offshoring to Asian countries largely began in the 1960s (Brown et al. 2005). Moreover, the many rules and regulations in India made it such that firms found an easier time rent-seeking than achieving greater efficiency. Much more energy was spent in gaining the appropriate licenses and fulfilling foreign exchange requirements than was spent on increasing efficiency and the level of value added in products and services.

In the electronics sector import substitution was not as effective as it could have been, because of a desire to make SSIs efficient (a near impossibility). There was also a desire to enter at the technological frontier, such that even the few joint ventures that did exist were not effective at transferring technical know-how. Most important is that at no time had India followed the schemes laid out by other successful developing countries, which tied performance standards to many of the benefits that came to firms as a result of liberalization. In India, the removal of restrictions on imports were not tied to performance standards, such as ones requiring a certain percentage of a firm's profits to be invested in R&D (Amsden 2004). So as a consequence of

liberalization in the 1980s, color televisions and other major products came to be assembled as kits, damaging India's chances of meeting consumer expectations, even after India later placed a ban on the process of kit assembly. Thus the process of liberalization held back growth of the electronics industry within India.

While some have credited the liberalization occurring with the 1984 computer policy for pushing production up 100 percent and prices down 50 percent, the production of computers had increased by over 300 percent from 1980 to 1982, well before this policy was enacted (Alam 1990).

6.1.1. Policies and Outward Orientation

To prevent the heavy reliance on these kits without infringing on trade rules, India could have used methods practiced by other developing countries that promoted the use of local standards to protect against imports. Specifically, promoting local standardization of components for end-use products, such as color TVs would have been useful as a mode of import-substitution. As indicated by India's experience in ICs for watch production, establishing local standards for ICs created a substantial and beneficial demand for these ICs (Alam 1990). Promoting the use of these local standards would have encouraged those firms not using BEL's color TV chips in the 1980s to use locally developed designs. This would have satisfied a high-tech version of import substitution, allowing for domestic firms to thrive.

Instead, India has mainly pursued international standards, with the rationale being that this will allow India to both sell products to a great degree on the international market, and import standardized products to cut local costs. However, this use of internationally standardized products to promote exports has been misguided. Even ICs that are exported are of such high costs and poor quality that international demand for them is not high, and they are not profitable. The primary result has been a huge amount of imports for the purpose of exploiting the domestic market: with foreign MNCs showing great interest in pursuing production in India for the sake of selling in India. By following international technological standards so completely, India has opened itself to greater capital flight. On the other hand, in China, which has followed local standards, especially in telecommunications, capital investments have remained more static

(Linden 2004). Although some scholars believe that following these international standards may cause factor prices to converge – limiting the international mobility of capital – it is unlikely that these factor prices would converge completely, and there would still be great incentives for capital to move out of countries like India.

6.1.2. Policies and Firm Size

The misguided promotion of SSIs prevented the emergence of many large domestic firms within the consumer electronics arena. Those policies reflected an inability to realize that electronic components were capital intensive activities, and that India has wrongly reserved most of this activity to small firms as a means for spreading employment.

Even after restrictions on firm size were eased, many of the small firms continued to assemble kits, competing on the basis of price more than the diversity of the product. With the intense competition, they could not afford to research and develop their own designs. Rather they often felt forced to import designs and knock-down kits rather than design in-house. Furthermore, the small scale units appear to have established some regional brand loyalty, probably because the kits they assembled were of high international quality. This prevented competition from some of the larger firms, who were subsequently forced to compete on the national level where small scale firms held less of the market. For this reason, we now see large firms at the forefront of the nation, able to participate in R&D and develop specialized chips, which are called for after long periods of homogeneous products.

With the liberalization of rules regarding firm size only two firms, Phillips and BPL-Sanya, were able to retain a significant share of the color TV Industry, and they were able to do so mainly because of their capabilities despite liberalization, not because of liberalization. Unlike many other firms, they had for many years engaged in establishing networks with high quality local suppliers, allowing them to continue locally after liberalization. Similar observations about timing when it comes to liberalization have been previously made (Amsden 2003), and suggest that the huge rise in mergers and acquisitions in India, which began in the early 1980s, were indicative of a premature shift from import-substitution to liberalization.

The effort to promote these firms also ignored the great dependency of these small firms on things other than fiscal incentives, including provisions of infrastructure and communication, something that India's EPZs and now SEZs have provided little of. In large firms the need for networking is less, so these provisions can obviously be smaller, and large firms also have the capabilities to establish many of these necessities themselves. India's fundamental misconception in promoting SSIs was that employment can be best created by establishing industry near the people, when the experience of most developing countries shows that it has been more beneficial to allow persons to move toward industry, as is the case with large firms and large industrial communities.

The practice of limiting large firm involvement in many of the subsectors of electronics was counter to the goal of expanding employment to many regions. Many firms were forced to remain smaller than they would be by limiting their investments in manufacturing machinery and testing facilities. In response, many firms diversified into making several items, such as color TVs and watches using the same capital. However, these firms would end up producing numerous different items at a still inefficient scale. The strategy to manufacture everything that can be possibly manufactured was most damaging for the Indian electronics sector. This caused India to rely very heavily on imports; not able to keep up with the fast paced technological change.

Given that these larger firms operated in many different sub-sectors, Indian policies should have been geared toward the amount of revenues a firm received in a particular sub-sector, not the size of the firm itself. Focusing on the revenues in each sub-sector rather than the size of the firm, would have allowed many firms to grow in size, and gain the project execution capability (Amsden 2003) that they lacked (See Appendix). Furthermore, it would have allowed for firms to better make use of shared capital costs, while likely maintaining the same objective of spreading employment to many different regions.

As shown in Figure 11, when producing a given output of Q_1, a decrease in the cost of capital causes an initial decrease in the amount of labor used (A to B). With this money saved on capital though, there is also an expanse in production that leads to greater than the initial output. India

has severely limited production in this sector by concentrating on overall firm size. The result of this is shown in Figure 11, where expanded production yields less than optimal labor compared to Figure 12, where the freedom to grow large by considering overall firm size allows for even more employment.

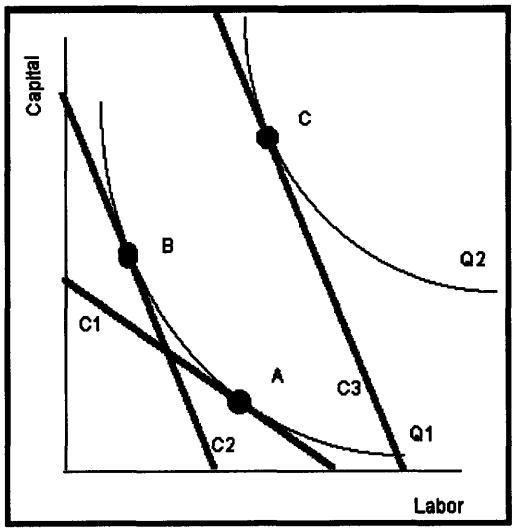

Figure 11: Falling Costs of Capital - Substitution Effect Dominates

Source: (Abowd 1999)

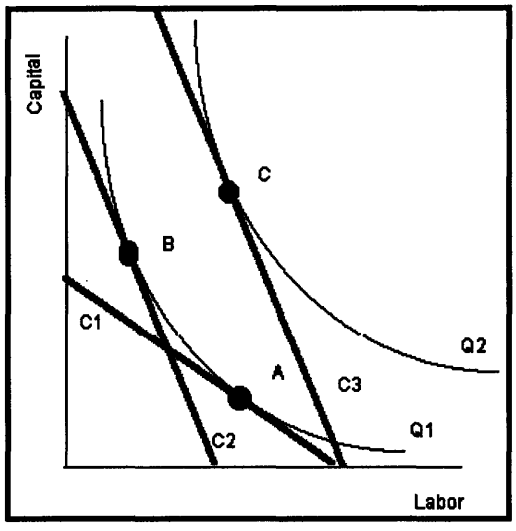

Figure 12: Falling Costs of Capital - Expansion Effect Dominates

Source: (Abowd 1999)

The capital for labor substitution was heavily related to the technology itself; thus, the rate of employment growth shifted toward capital as the technology advances, regardless of policies. This did in fact happen, and despite the claims of employment growth, it actually slowed overall. The growth in employees/factory – which is often cited as employment growth under liberalization – was fueled by a decline in the number of SSI factories that outpaced the number of employees in the pre-liberalization period.

6.1.3. Policies and Ownership

The firms within India have specialized in assembly and design, but not so much in fabrication. This has been an interesting development path, considering that assembly is relatively low skill, and accounts for only 6 percent of the engineering employment, while design accounts for 85 percent engineering employment. Fabrication, which accounts for 24 percent engineering employment currently, is the middle step between heavy capital intensity and heavy skill-intensity that India seems to have skipped.

Currently though, India must look to its current focus on design to assess how to promote or maintain some level of employment. The captive offshore units are fairly mobile, and thus they can easily move to other low cost locations. With India attempting to create labor-intensive manufacturing through small sector units, it has encouraged the short-term industry focus on reducing costs. This focus on the share of wages in profits, India has ignored the paradigm of achieving dynamic comparative advantage through delayed gratification. India will best achieve high levels of R&D and investment as their industry grows, and not the other way around. The same can be said of employment, that it will come with growth, not by artificially creating a high-labor ratio, which makes other low-wage countries more attractive. In design services, wages have risen dramatically, but this is more indicative of India's failure to supply appropriately skilled labor than it is of less stringent labor regulations in this subsector.

Currently, India is falling behind its biggest new competitor in the electronics industry: China. increased the size of its industry greatly, and it now accounts for 8 percent of their industrial output, India has a much smaller industrial output in general, and of this the electronics sector

accounts for only 3 percent (Yusuf et al. 1980). Now with many of the newly industrialized economies moving into higher value added activity, India must compete with countries like China to solidify its position in this market, without compromising its share of related services in the electronics industry, such as the software market.

6.2. Recommendations

6.2.1. Talent Generation

India has created a self-induced Diaspora, by limiting its supply of IIT caliber institutions. At the same time, it is this Diaspora that has furthered knowledge of global networks. Many Indian managers don't mind the migration, and they actually encourage it. One of the key ways for a firm to find out about their competitors in this fast paced market has been to employ the high job mobility whereby workers constantly rotate from firm to firm. This high job mobility prevents any one firm from gaining a large advantage over another (Brunner 1991). This job mobility has been the best mode of linkage that India maintains for its small scale sector, and it so happens to be greatest in the more successful software arena. In a study that inquired how computer and software companies gained information about foreign and domestic competitors (their technologies and processes), most companies stated that hiring away competitors employees was a great way of gaining information; increasing the high job mobility of computer and software experts (Brunner 1991).

However, in order to drive their electronics industry to the extent that China has (and ensure that employees that are contracted out do in fact return), India must grant extra incentives for would-be returnees to bring new startups to the country. Many of these stakeholders have thus taken to creating independent institutes for the purpose of training Indians in chip design. For instance, the company eInfochips has collaborated with Calorex Institute of Technology to offer a diploma in VLSI design (Janardhan 2003). It would be more beneficial for the government to actively encourage such practices.

With the growth of this industry, and the continuing rise in wages, India may experience a rise in its "reverse brain drain." Additionally, firms and industry groups may place more pressure on the government to set up new or expand old institutions, creating new talent, while simultaneously keeping it within the country.

6.2.2. Socio Economic Considerations

The relatively stagnant wages within India have been an obstacle to growth in the industry as a whole. Given that the industry is mainly focused on the Indian market, these low wages have had the perverse effect of lowering the purchasing power of Indian consumers (Banerjee 2005).

The rising share of profits bodes particular ill for India because of the inter-industry involvement of many of India's biggest firms. These firms, which find great variation in rents by moving capital, but small variations through labor mobility, may often find it often very profitable to decrease either wages or labor in any given venture at any given time. Therefore, the smallest differences in profit potential can have particular allocation consequences for the Indian electronics sector. Because these large and diversified business groups have been able to allocate resources efficiently both between sectors and within sectors, as opposed to simply within the sector, they may also promote both intra- and inter-industry wage inequalities.

Because India has such a significant quantity of scientists and engineers, the wage rate has been fairly low in comparison to what it would have been in many countries. Despite the growth in the electronics industry since the 1980s (Banerjee 2005), and a rise in the productivity of the average worker, the share of wages in net income has declined. Conversely, the share of profits in income has increased. By cutting back on wages, the ODM firms – which are better positioned to cut labor costs than foundries or EMS firms – have been able to establish the highest gross margins within the electronics industry. The ability of ODM firms to cut back on wages has been heavily premised on their ability to maintain small firms in disparate regions, limiting the workers' ability to unionize.

Therefore, the largest firms with the largest wages, whereas smaller firms with high profit margins have arisen in areas where these labor market regulations are weakest. The government can play a role in facilitating cooperation amongst these firms, saving them small amounts on shared capital that can be potentially applied to workers' wages. This strategy would allow ODMs to rise to the frontier of the industry, turning their gross margins into large total revenues. Furthermore, this selective targeting should be aimed at other industry segments that are small, yet profitable. Currently, smaller analog chip companies are growing at a much faster rate than the overall market. Promoting these smaller analog chip companies represents an excellent opportunity for India.

6.2.3. Tax Structure

The tax havens that India has used to promote its electronics industry, such as SEZs, require extreme cautionary use in the future. Currently, much of the investment coming into India has come in the form of foreign portfolio investment, rather than foreign direct investment. Therefore investments are fairly fluid, and India must avoid a rush of capital flight in the face of global slowdowns or financial shocks.

One manner, in which India can ensure investment is more stable, is to tie performance standards to use of tax-free zones, like SEZs. Large MNC Firms have already begun employing such standards, such as those firms like Flextronics and Nokia, which have been building their own industrial campuses, avoiding the use of government SEZs.

6.2.4. Regulatory Preferences

A key lesson for India should be that it should have a greater concentration on its domestic market for the meantime, as shorter product-life cycles, and especially market volatility, make this international market a weak substitute for India's large potential in the domestic market. The domestic market appears to be less risky, and has given companies a greater chance to obtain user input to apply during the product development process.

India must complement its domestic servicing with similar products for the international market. For instance, India could actively select and promote those products that do not necessarily use the newest equipment. The growing use of old equipment in analog production may explain why the growth of 12-inch wafer production has corresponded with a growth of the older, 8-inch wafer production.

A common criticism of BEL had been that it used equipment over 15 years old in its production process. As seemingly bad is this was, it seems that a larger issue was the types of chips that they were attempting to develop with that technology. Having focused their chips toward a domestic market that was not receptive, they neglected to produce the types of chips that would have been most profitable on the international scene, given the technology they currently possessed. For example, given a design sector which showed some strength since the 1970s, India could have specialized more in analog design or some other design with regulations that better captured the skills of its employees to use on the international scene.

India's increased focus on chip design, as well as software design, must achieve high levels of value added in the design to make up for the small, locally-owned manufacturing sector within the country. A significant coordinated effort must be made if India is to perform more of the design work that is currently performed to a greater extent by the US, China, and Taiwan (EE Times 2005). Based on a KPMG survey, the most important skills currently within the industry are the design of analog devices, with digital hardware and software design coming behind analog design; and all of which are more important than skills related to manufacturing process R&D (KPMG 2005) .

The most important design skills, that of analog design, are very different from the standard design skills. As shown in Figure 13, analog circuits are a relatively small, but still substantial portion of a large integrated circuits market.

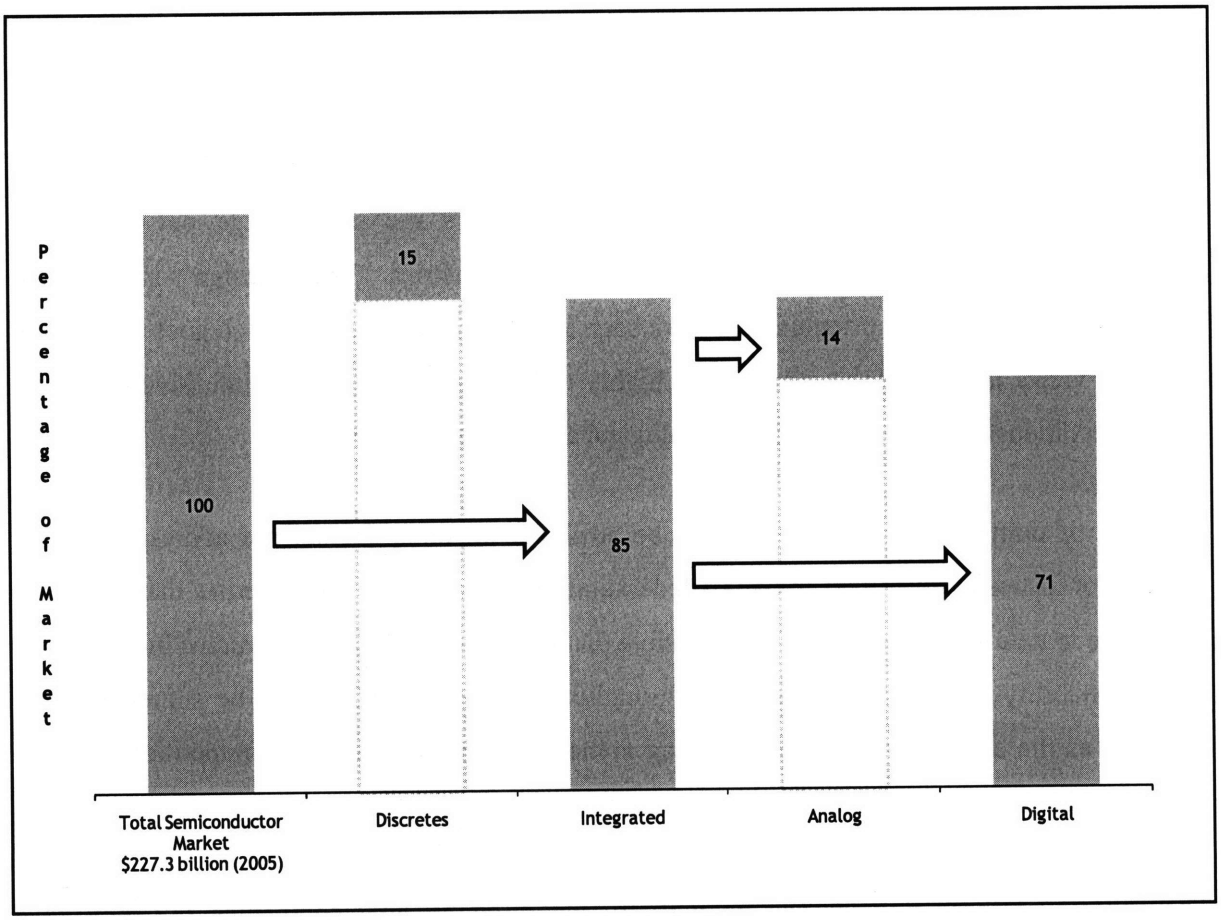

Figure 13: Role of Integrated Circuits in the Semiconductor Market

Source: (Plan B Manufacturing, Ltd. 2007)

These analog chips, which account for 17 percent of the IC market and 14 percent of the semiconductor market, exhibit the same variance (accuracy in its electrical properties) found in most chips. However, this issue of variance is more important for analog chips, which must rely on continuous electronic signals, than it is in digital electronic chips. Because this variance becomes less of an issue with bigger chips, analog chips often use older technology. Equally important to India's involvement with analog design, is the fact that analog chips cannot be easily standardized, resulting in design work that is more individualistic than team-based and with a lesser ability to automate many aspects of the design. Although this is currently valued as the most important skill for the industry, there are only 400 analog designers in India with more than 3 years experience, whereas there are 10,000 digital design engineers (Plan B Manufacturing, Ltd. 2007).

6.3. Future Work

India has failed to achieve proper import substitution within the electronics manufacturing arena, leaving most of its global production at a low-level; yet the growth of design services has mushroomed. The export-led growth in design services did not emerge out of import substitution, which is the typical case for high export industries. These design services have been very naturally export oriented, and have been highly labor intensive, which goes against the orthodox views that the high-tech arena is highly technological and capital intensive (although the indirect industry benefits may be technological and capital intensive).

The lack of domestic manufacturing may be attributed to other factors not addressed in this thesis. For instance, given that India is a federation of 29 states, with state parties that owe little allegiance to national parties, it may be possible that business stakeholders *perceive* India to have a lower stability of government policies throughout the nation. This may be somewhat well founded, as the disaggregated policy making arena, has created extensive competition between states to offer higher positive incentives for business to locate within the area.

The success of these policies can be partially measured by how companies say they have influenced the labor, corruption, and infrastructure ratings of these countries. Figure 14 shows these ratings for the six states that make up 80 percent of the FDI in India. Many are successful states, including Karnataka and Maharashtra, so more research should be done to evaluate whether or not these are in fact obstacles.

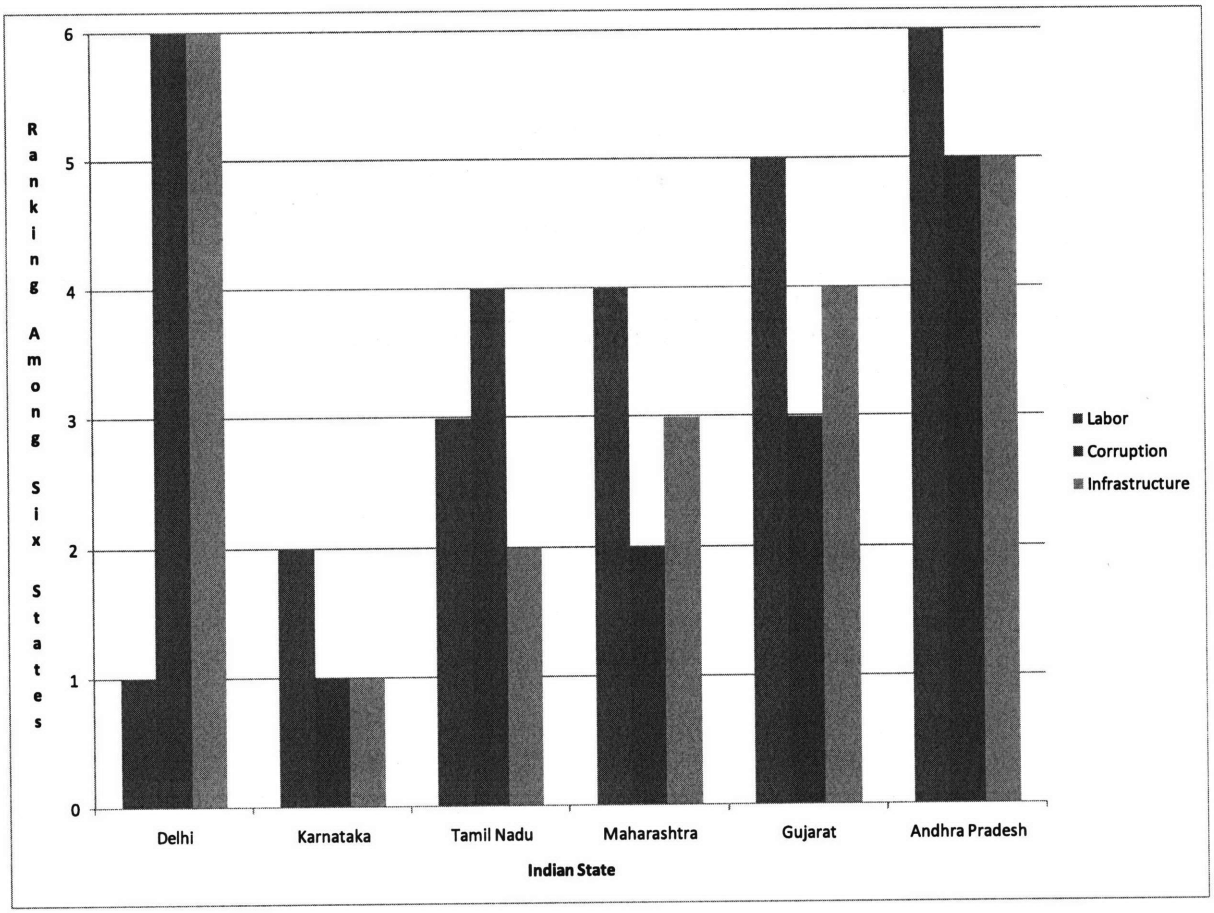

Figure 14: Severity of Labor, Corruption, and Infrastructure Obstacles

Source: (India Brand Equity Foundation 2006)

Additionally, given this lack of domestic manufacturing, more research is needed to assess the quality of engineers within the design arena. As we can see in Table 30, India has a higher average salary than China, even as it has no fabrication centers, and fewer chip designers. Furthermore, India's engineers receive a favorable salary compared to Taiwan's engineers, even as India has no fabrication centers and much fewer chip designers (Brown and Linden 2006). The implication is that the quality of chip designers plays a significant role in the industry. As stated at the beginning of this thesis, there is a need to better evaluate quality of not only the products manufactured, but also the engineers that are employed.

Table 30: Cost Location of Designers and IP Protection

Country	Annual EE/CS engineer salary	Value of fabs constructed by country of ownership, 1995-2006	Number of chip designers	Intellectual Property Protection 2002 (10 = high)
United States	$82,000	$74 billion	45,000	8.7
Japan	$60,000	$66 billion	N/A	6.2
Taiwan	$30,000	$72 billion	14,000	6.7
China	$12,000	$26 billion	7,000	4.0
India	$15,000	$0	4,000	4.2

Source: (Brown and Linden 2006)

The author of this thesis would like to express his gratitude to the readers of this thesis. It is hoped that ideas presented in this thesis will be useful for readers.

Appendix A: History of Indian Electronics Industry

Milestone	Year	Remark
1. Bhaba Committee	1966	Recommended development of an integrated electronics sector to achieve self reliance with minimal recourse to foreign capital and dominant role to the public and small-scale sectors.
2. Hardware Imports	1972	Hardware imports permitted if the hardware was used for software development purposes on condition that the cost was recouped from foreign exchange earnings over 5 years.
3. Hardware Imports II	1976	Hardware import duties reduced from over 100% to 40% faster clearance of software export applications; software exporters could take advantage of export incentives including locating in Export Processing Zones (EPZs); non-resident Indians allowed to import hardware for the purposes of software export with a 100% export obligation
4. Sondhi Committee	1979	Recommended dismantling of controls in general and of MRTP and FERA companies in particular.
5. Menon Committee	1979	Recommended liberalization of import of foreign capital and technology and duty-free import of capital equipment.
6. Hardware Imports III	1981	Import duties on hardware were raised but firms were allowed to use hardware for the development of domestic software as well as for exports; software exporters could also import "loaned" computers.
7. Components Policy	1981	De-licensing of component manufacture except for MRTP and FERA companies. Provision of 40 percent equity to FERA companies in high technology areas. No clearance required under Sections 21 and 22 of MRTP Act except for VSI and VLSI. General reduction in duty on components and liberal import of capital goods for component manufacture.
8. Color TV Policy	1983	Ceiling on capacity was removed. All sectors of industry, excluding foreign companies, were allowed to participate.
9. Telecommunication Policy	1984	Telecommunication was opened to private sector.
10. Computer Policy	1984	All Indian companies, including FERA companies, were allowed to enter the computer industry with no restriction on capacity. Most of the components needed were put under Open General License List to facilitate import. a. Reduced the tariffs on PCs from 135% to 60%

		and this led to higher number of PCs being imported; b. Recognized that software exports as a "delicensed activity" and this enabled the firms to be able to access bank finance for exports; c. Permitted international firms to set up wholly owned, export-dedicated enterprises; d. Planned to set up a chain of software parks and that would offer infrastructure at below-market costs; and e. Income tax exemption on net export earnings reduced from 100% to 50%.
11. Integrated Policy	1985	De-reserved certain components of small-scale sector. Introduced broad-banding and liberal approach towards foreign companies even with more than 40 percent equity in high technology areas.
12. Computer Software Policy	1987	Reduction in the duty on all imports meant for software exports and no duty for hundred percent export. Provision of special financing schemes and permission for foreign companies (with more than 40 percent equity) in the 100 percent export projects. a. Software imports at a 60% duty b. 100% export oriented software production units were permitted to import hardware duty-free c. Export obligations for hardware importers increased by 50% and the time in which to meet the obligations reduced to four years.
13. Software Technology Parks	1988	Creation of software technology parks for the production of software for export together with special incentives. a. Zero import duty on import of all capital goods b. A special 10 year income tax holiday c. Provision of infrastructural facilities like high speed data-communication links etc.
14. Electronics & Computer Software Export Promotion Council	1988	The Electronics and Computer Software Export Promotion Council was set up to provide marketing help to software companies in their exports. The government also began programmes to assist exporters with provision of export credit and insurance.
15. New Industrial Policy	1991	Economy-wide liberalization programme introduced, which included reducing the import duties on software gradually to 10% by 1995. Software exports broguth under the Income Tax laws and exempted exporters from income tax.

Source: (Joseph 2004); (Veloso et al. 2003)

Appendix B: Current Government Policies

Policy	Characteristics
FDI	a. Up to 100% equity allowed in exchange for exports (Domestic Tarriff Areas) b. Approval for setting up units in EPZs given by Ministry of Commerce c. Approval for Setting up EOU outside the EPZs given by Ministry of Industry d. Approval for Setting up by STPs and EHTPs given by Inter-ministerial Standing Committee (IMSC) under Department of Information Technology e. Other Proposals considered by the Foreign Investment Promotion Board (FIPB) f. A portion may be sold in the DTA depending on the value-added
Non-automated FDI when	a. Items requiring an Industrial License under the Industries (Development and Regulation) Act of 1951. b. More than 24% equity when manufactured items are reserved for small scale industries. c. Items which must adhere to a locational policy under the New Industrial Policy of 1991. d. Proposals where the foreign collaborator has a previous venture/tie-up in India
Foreign Technology Collaborations	a. Approved by the Reserve Bank of India (RBI) or otherwise by FIPB.
Non-automated Foreign Technology Collaboration Agreements when	a. Lump sum payment of the price of the technology exceeds $2 million b. Royalty payments exceed 5% of domestic sales and 8% of exports (net of taxes) c. Payments exceed 8% of total sales over a period of 10 years from date of agreement or 7 years from the date of first production, whichever is earlier.
Electronics Hardware Technology Parks	a. 100% permissible foreign equity b. No duties on components, raw materials, and capital goods c. Access to Indian domestic market is allowed up to 50% of the free-on-board value exports d. Can be set up for both software and hardware operations in an integrated manner.
Special Economic Zones Policy (2000, amended 2005)	a. Duty free b. No license required for import c. Manufacturing or service activities allowed d. Must be net foreign exchange earners within three years e. Domestic sales subject to full customs duty and import policy in force. f. Full freedom for subcontracting. g. No routine examination by customs authorities of export/import cargo

International Policies	a. India is a signatory to the World Trade Organizations Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) b. The Information Technology Agreement (2005), resulted in zero customs duty on imports of all telecom equipment. c. India's Foreign Trade Policy 2004 - 2009 permits import of all kinds of computers (Except second hand computers) in India without any licenses.

Source: Various

Appendix C: Technological Capabilities

Production Capability

Production management – to oversee operation of established facilities
Production engineering – to provide information required to optimize operation of established facilities, including the following:

1. Raw material control: to sort and grade inputs, seek improved inputs
2. Production scheduling: to coordinate production processes across products and facilities
3. Quality control: to monitor conformance with product standards and to upgrade them
4. Trouble-shooting to overcome problems encountered in course of operation
5. Adaptations of processes and products: to respond to changing circumstances and increase productivity
6. Repair and maintenance of physical capital, according to regular schedule and when needed.

Project Execution (Investment Capability)

Personnel training – to impart skills and abilities of all kinds
Preinvestment feasibility studies – to identify possible projects and ascertain prospects for viability under alternative design concepts
Project execution – to establish or expand facilities, including the following:

1. Project management: to organize and oversee activities involved in project execution
2. Project engineering: to provide information needed to make technology operational in particular setting, including the following:
    a. Detailed studies (to make tentative choices among design alternatives)
    b. Basic engineering (to supply core technology in terms of process flows, material and energy balances, specifications of principal equipment, plant layout)
    c. Detailed engineering (to supply peripheral technology in terms of complex specifications for all physical capital, architectural) and engineering plans, construction and equipment installation specifications)
3. Procurement (to choose, coordinate, and supervise hardware suppliers and construction contractors)
4. Embodiment in physical capital (to accomplish site preparation, construction, phase erection, manufacture of machinery and equipment)
5. Start-up of operations (to attain predetermined norms innovation capability)

Innovation Capability

The skills necessary to create new products or processes, the type of skills depending on the novelty of the new technology.

1. *Pure science*: the search for intrinsic knowledge
2. *Basic research*: the search for radically new technology
3. *Applied research*: the search for differentiated products
4. *Exploratory research*: the search for refinements of differentiated products
5. *Advanced development*: the search for the optimum manufacturability of refined differentiated products

Source: (Amsden 2003)

Appendix D: List of Acronyms

BEL – Bharat Electronics Limited
CAGR – Compound Annual Growth Rate
CSIR – Center for Scientific and Industrial Research
ECIL – Electronics Corporation of India Limited
EHTP – Electronics Hardware Technology Park
EMS – Electronics Manufacturing Service
EOU – Export Oriented Units
EPZ – Export Processing Zone
FDI – Foreign Direct Investment
FERA – Foreign Exchange Regulation Act
FIPB – Foreign Investment Promotion Board
GDP = Gross Domestic Product
IC – Integrated Circuit
IP – Intellectual Property
LCD – Liquid Crystal Display
MNC – Multinational Corporation
MRTP – Monopoly and Restrictive Trade Practices Act
NRI – Non Resident Indian
NSIC – National Small Industries Corporation
ODM – Original Design Manufacturers
OEM – Original Equipment Manufacturer
PSE – Public Sector Enterprises
R&D – Research and Development
SCL – Semiconductor Complex Limited
SEZ – Special Economic Zones
SSI – Small Scale Industries
STP – Software Technology Park
TRIMS – Trade Related Investment Measures
WTO – World Electronics Organization

References

Abowd, J. M. (1999) Factor Markets. <http://instruct1.cit.cornell.edu/courses/econ101-dl/lecture-factor-markets.html> accessed on 13 April 2008

Agarwal, S. M. (1985) Electronics in India: past strategies and future possibilities. *World Develpment,* 13, 273-292.

Amsden, A. (2004) Import substitution in high-tech industries: Prebisch lives in Asia! *CEPAL Review,* 82, 77-91.

Amsden, A. H. (1997) Editorial: Bringing production back in: Understanding Government's economic role in late industrialization. *World Development,* 25, 469-480.

Amsden, A. H. (2003) *The Rise of" The Rest": Challenges to the West from Late-Industrializing Economies.*

Amsden, A. H. (2005) Import Substitution in High-Tech Industries. *CEPAL Review,* 82, 75-89.

Arrow, K. J. (1962) The Economic Implications of Learning by Doing. *The Review of Economic Studies,* 29, 155-173.

Banerjee, D. (2005) *Globalisation, industrial restructuring and labour standards.*

Benitah, M. (2004) *Subsidies, Services and Sustainable Development,* International Centre for Trade and Sustainable Development.

Bindra, A. RF Design. (2005) IC Design Industry Flourishes in India.

Brown, C. & Linden, G. (2006) Semiconductor Engineers in a Global Economy. *National Academy of Engineering, Workshop on the Offshoring of Engineering: Facts, Myths, Unknowns, and Implications.*

Brown, C., Linden, G., Berkeley, U. C., Leachman, R., Obukhova, E., Pillai, D., Shuen, A., Smith, G., Marketing, S. & Appleyard, H. C. (2005) Offshoring in the Semiconductor Industry. *Brookings Trade Forum,* 2005, 279-322.

Brunner, H. P. (1991) Building Technological Capacity: A Case Study of the Computer Industry in India, 1975-87. *World Development,* 19, 1737-1751.

Carbone, J. Purchasing. (2005) India Takes First Steps in Electronics.

CIA. (2008) CIA-The World Factbook-India. <https://www.cia.gov/library/publications/the-world-factbook/geos/in.html> accessed on 17 March 2008

Clark, G. & Wolcott, S. (2003) One polity, many countries: Economic growth in india 1873-2000. *In Search of Prosperity: Analytic Narratives on Economic Growth. Princeton University Press: Princeton*, 53–79.

Confederation of Indian Industry. (2003) India's New Opportunity 2020.

Dasgupta, P. & Stiglitz, J. (1980) Industrial Structure and the Nature of Innovative Activity. *Economic Journal,* 90, 266-293.

Dedrick, J. & Kraemer, K. L. (1993) India's quest for self-reliance in information technology: Costs and benefits of government intervention. *Asian Survey,* 33, 463-492.

Department of Electronics. (1988) *Annual Report.*

Department of Information Technology, Data Bank & Information Division. (1993) *Guide to Electronics Industry in India 1993.*

Department of Information Technology, Data Bank & Information Division. (2003) *Guide to Electronics Industry in India 2003-2004.*

Different, I. (1978) UTILISATION OF ELECTRONICS R and D IN INDIA. *Physics Technology,* 9.

Economist. (2007) Prowling Tiger.

EE Times. (2005) Outsourcing Research Report. <http://www.eetimes.com/register/articleLogin.jhtml;jsessionid=TXY55JY23PERSQSNDLPSKH0CJUNN2JVN?_requestid=672297> accessed on 31 March 2008

ELCINA Research. (2006) Indian Electronics Industry: Size of the Industry. <http://www.elcina.com/industry_size.asp> accessed on 31 March 2008

Evans, P. B. (1992) Indian Informatics in the 1980s: The Changing Character of State Involvement. *World Development,* 20, 1-18.

Evenett, S. (2002) Multilateral Disciplines and Government Procurement. *Hoekman B., Mattoo A., English P., op. cit.*

Express Computer India. (2003) Designs on the Future.

First Principles. (2006) Government preferential procurement policy: Catalyst for or inhibitor of innovation? .

Four Korners. (2008) Electronics. <http://www.4korners.org/images/img_electronics.jpg> accessed on 4 May 2008.

Galbraith, J. K. (1952) *American capitalism: The Concept of Countervailing Power*, Houghton Mifflin Boston.

Goldar, B. N. & Renganathan, V. S. (1998) Economic Reforms and R&D Expenditure in Industrial Firms in India. *Indian Economic Journal,* 46, 60–75.

Guhathakurta, S. (1994) Electronics Policy and the Television Manufacturing Industry: Lessons from India's Liberalization Efforts. *Economic Development and Cultural Change,* 42, 845-68.

GW Foster. (2007) Integrated Circuit. <http://gwfoster.com/QIE-Integrated-circuit.JPG> accessed on 7 April 2008.

India Brand Equity Foundation. (2006) Manufacturing in India.

India Brand Equity Foundation. (2007) A Blue Chip Biz.

India One Stop. (2008) India's Balance of Payments. <http://www.indiaonestop.com/economy/balanceofpayments/economy-macro-balance%20of%20payments.htm> accessed on 7 April 2008

International Trade Centre. (2004) SME and Export Led Growth.

Joseph, K. J. (2002) Growth of ICT and ICT for Development: Realities of the Myths of the Indian Experience. *United Nations University, Discussion Paper.*

Joseph, K. J. (2004) The Electronics Industry. *The Structure of Indian Industry.*

KPMG. (2005) Convergence Gathers Pace: Emerging Trends in Asia Pacific ICT Markets.

Kumar, N. & Aggarwal, A. (2005) Liberalization, outward orientation and in-house R&D activity of multinational and local firms: A quantitative exploration for Indian manufacturing. *Research Policy,* 34, 441-460.

Linden, G. (2004) China Standard Time: A Study in Strategic Industrial Policy. *Business and Politics,* 6, 4.

Mattoo, A. & Stern, R. M. (2003) *India and the WTO.*

National Portal of India: Commerce and Industries. (2008) Special Economic Zones. <http://india.gov.in/sectors/commerce/sezs.php> accessed on 7 April 2008

National Research Council. (2007) India's Changing Innovation System: Achievements, Challenges, and Opportunities for Cooperation: Report of a Symposium

Nations Online. (2008) Map of India. <http://www.nationsonline.org/bilder/map_of_india50.jpg> accessed on 7 April 2008.

New Yorker. (2007) India's Skills Famine: The Talk of the Town.

OECD Development Centre. (1990) The Indian Electronics Industry: Current Status, Perspectives, and Policy Options.

Papola, T. S. (2005) Emerging Structure of Indian Economy. *88th Conference of the Indian Economic Association.* Andhra University, Vishakhapatnam.

Plan B Manufacturing Ltd. (2006) India's Fast Growing Electronics Manufacturing Sector.

Plan B Manufacturing, Ltd. (2007) India Electronics Sector Opportunities for Beginners.

Prebisch, R. (1950) *The Economic Development of Latin America and Its Principal Problems.*

Ramakrishna, S. (1986) A Critical Appraisal of India's Exports or Electronics and Computer Software since 1986. Jamia Millia Islamia, New Delhi.

Schumpeter, J. A. (1942) *Capitalism, socialism, and democracy,* New York, Harper & Row.

Semiconductor Industry Association. (2008a) World Semiconductor Sales. <http://www.sia-online.org> accessed on 13 April 2008.

Semiconductor Industry Association. (2008b) Semiconductor Industry Association - Statistics. <http://www.sia-online.org/pre_statistics.cfm> accessed on 7 April 2008

Tiwari, V. (1993) Determinants of Invesment in Electronics Industry in India.

Veloso, F., Botelho, A. J. J., Tschang, T. & Amsden, A. (2003) Slicing the knowledge-based economy in Brazil, China and India: a tale of 3 software industries. *Massachusetts: Massachusetts Institute of Technology (MIT), set.*

Wellenius, B., Miller, A. & Dahlman, C. J. (1993) *Developing the Electronics Industry*, World Bank.

World Bank. (2004) India: Investment Climate and Manufacturing Industry.

Yusuf, S., Nabeshima, K. & Perkins, D. (1980) China and India Reshape Global Industrial Geography. *World,* 1990, 2004.