ROLE OF GOVERNMENT IN THE GROWTH OF INDIA'S SOFTWARE INDUSTRY

BROJO PAUL JOSEPH PILLAI

NATIONAL UNIVERSITY OF SINGAPORE

2006

ROLE OF GOVERNMENT IN THE GROWTH OF INDIA'S SOFTWARE INDUSTRY

BROJO PAUL JOSEPH PILLAI
(*B.Comp. (Hons.), NUS*)

A THESIS SUBMITTED

FOR THE DEGREE OF MASTER OF SCIENCE

SCHOOL OF COMPUTING

NATIONAL UNIVERSITY OF SINGAPORE

2006

Acknowledgment

I thank my supervisor, Professor K.S. Raman, for his constant guidance through these years. In the process of putting together this thesis, many people gave freely of their time: the numerous interviewees in India, Dr. Atreyi Kankanhalli, Dr. Bock Gee Woo, and my good friend Sibi Venkataraju. The Indian High Commission (Singapore), STPI (Bangalore, Hyderabad) and the Governments of Karnataka and Andhra Pradesh were of invaluable help in data collection. As is often said, anything good in this thesis is largely due to the guidance of these individuals, while I am responsible for any shortcoming.

Table of Contents

Summary

The dramatic growth of the software industry in India has continued past the technology and Y2K boom of 2000. According to some sources, India is the second largest exporter of software in the world, next to the US. The industry has been growing at over 50 percent per year for the past ten years, compared to a global growth rate of about 12 percent, and has emerged as the major export earner for the country.

This study adopts an interpretive case study research methodology in studying this growth, and investigating the factors behind it. Interviews conducted in India, and various secondary sources including official data, data from industry sources, research articles and trade journal reports contributed to this study.

The contributions of this study lie in bringing further clarity to the role of the Government of India in the success of its software industry. This is an area in which many negative things have been said about the Government, but few positive things. This study brings to light several interesting facts, stories and anecdotal evidence of a positive role that the Government (also) played. Its conceptual contribution comes from the application of an OECD model ("Role of innovation in ICT in economic growth performance": OECD, 2000) to this case, providing insights into ways of expanding the model. The study also helps to bring realism to the efforts of Governments of different countries in attempting to imitate India's success. A further contribution of this study is an updated assimilation of the history of the Indian software industry, since its inception until 2005, and it's clustering in a few locations. A model of classifying companies in the industry has been developed, called the "Value Pyramid". Lastly, the study shows how the Silicon Valley model of growth was different from the model of growth of Bangalore, India's Silicon Valley, and introduces a figure illustrating Bangalore's software cluster.

The key finding of this study is that contrary to popular perception, the Government of India played a significant positive role in the growth of India’s software industry through a three-pronged approach of (1) Policy support (2) Infrastructure support and (3) Human resource support; that resulted in the growth of clusters of software excellence scattered across India.

List of Tables

List of Figures

Chapter 1: Introduction

1.1 Introduction

Today, despite a low literacy rate of 61%, a Human Development Index ranking of 124, an Internet penetration of just 1%, and 267 million people below the poverty line, several Indian locations are ranked among the world's leading centres for information and telecommunication technologies (ICT) (UIS, 2005; Arora *et al.,* 2001; Rosenberg, 2002; Roy, 2005). The Indian software industry has grown at over 50 percent per year during the 1990s compared to a global growth rate of about 12 percent (Bajpai and Shastry, 1998) and emerged as a major export earner for the country. This phenomenal growth has continued in recent years despite the global economic recession between 2001 and 2003. In 1985, the industry exported software and services worth US$ 24.51 million; in 2003-2004, a total export of US$ 12.5 billion was achieved and it is expected that during 2004-2005, software exports will be worth US$ 16.3 billion (NASSCOM). Foreign investment flows in, as the world takes greater interest in India, whether it is from AOL, Dell, Compaq, IBM, Deutsch Bank, or Microsoft. A report by NASSCOM & McKinsey on India's IT industry (1999) has set a target of US$ 50 billion of annual IT software and services exports to be achieved by 2008. Exaggerated in its ambition, the target reflects national expectations of the industry. Given this performance and the expectations of the industry, it is not surprising that Lawrence Klein, an Economics Nobel Laureate, included India in his list of three countries (cited in Ein-Dor, *et al*., 1997) that are capable of sustained economic growth based on the premise that productivity increase in Information Technology can fuel economic growth (the two other countries being Israel and Ireland[1]).

[1] Dr Lawrence Klein, in email correspondence, indicates that all three of the I's (India, Ireland, Israel) "benefit greatly because of the role of English in their advanced educational systems".

This success seems incredible given the political and economic history of the country over the past 50 years. The history is characterized by instability (one government lasted for less than 14 days), lack of direction, coalition governments, and confrontation among political parties. The past decade has seen six governments, four prime ministers, one war, a nuclear test, rise in aggressive federalism and several financial scandals of staggering proportion. The people's perception of government and public administration is negative. Successive governments have lacked vision when it came to the role of technology in the future of the country; and where they did not lack vision, they lacked relevance. There is a wide gap between policy making and policy implementation, and no efforts are made to bridge this gap. The infrastructure—physical, telecommunications, and particularly power—continues to be substandard. Public administration is sluggish and economic reforms have proven conducive to corruption (Roy, 2005). Over the years India has earned the dubious distinction of being one of the most corrupt countries, with a rank of 90 out of 146 countries (Roy, 2005; Transparency International, 2005) and the most bureaucratic (Roy, 2005). Politicians are known to buy votes and Politics functions on a system of patronage (Transparency International, 2005: Country Report, India). Some western observers have called India a functioning anarchy.

1.2 Motivation for the study

Emergence of India as a world class software powerhouse amidst this extreme democracy and anarchy confounds observers and raises some interesting questions. Is the growth of the industry for real? What are the drivers and success factors of this growth? Is this growth sustainable? What role, if any, has the government played in this growth?

Role of government in the growth of India's software industry is an interesting research topic for several reasons. First, some studies (Dedrick and Kraemer, 1998; Ein-Dor, *et al.,* 1997) are focused on developed economies and hardware with the software aspect of the industry not being studied in detail. Second, prior studies on the industry dwell on specific success factors such as human resources (Fernandes, 2001), or market forces (Bresnahan *et al*, 2001), without adequately discussing the Government's role in these. Third, while some studies (notably Heeks, 1996) do cover the role of Government, they often describe the Government's role as being largely limited to ineffectual policy-making or "benign neglect" (Singh, 2003; Arora *et al.*, 2001). Interestingly, our preliminary interviews suggested that this was not the case. Fourth, according to prior studies, governments have played a key role in the rapid growth of industries, especially in Japan and the Asian Tiger economies (Dedrick and Kraemer, 1998; Liu, 2001). Yet, in India, successive governments have regulated and constrained private industries. As N. Vittal (Secretary, Department of Electronics, Government of India) put it in a letter to us, "The approach of the Government was dominated by the controls culture which was typical of the Government of India's approach to industry. Thanks to Nehruvian Socialism, the approach of the government was to control the commanding heights of the economy."[2] These reasons made "Role of Government" a particularly interesting study.

1.3 Contributions of the study

The contributions of this study lie in bringing further clarity to the role of the Government of India in the success of its software industry. This is an area in which many negative things have been said about the Government. This study brings to light interesting facts, stories and anecdotal evidence of a positive role that the Government (also) played. Its conceptual contribution comes from the application of an OECD model ("Role of innovation in ICT in economic growth performance": OECD, 2000) to this case, providing insights into ways of expanding the model. The

[2] Vittal cites two examples: "(1) In addition to prohibitive set-up fees to export software (TI paid US$ 1m per year for connectivity), there were procedural issues such as the requirement that an Engineer of DoE (Department of Electronics) check five minutes of the transmission each day. (2) The criteria for eligibility to Software Technology Parks were devised in a way that neutralized the cost advantages of the Indian companies, thereby eroding their competitiveness."

study also helps to bring realism to the efforts of Governments of different countries in attempting to imitate India's success. A further contribution of this study is an updated assimilation of the history of the Indian software industry, since its inception until 2005, and it's clustering in a few locations. A model of classifying companies in the industry has been developed, called the "Value Pyramid". Lastly, the study shows how the Silicon Valley model of growth was different from the model of growth of Bangalore, India's Silicon Valley, and introduces a figure illustrating Bangalore's software cluster.

1.4 Thesis organization

The thesis is organized as follows—

- Chapter 1 introduces the thesis topic, highlights the motivation for the study, and discusses its contribution.
- Chapter 2 is a literature review, covering role of government in promoting the Software Industry, identifying an appropriate model that can be used to study this role, and cluster theory.
- Chapter 3 details the research methodology used in this study.
- Chapter 4 gives a background of the case.
- Chapter 5 details the findings on the Role of Government in policy, infrastructure and human capital support; the enhanced OECD model is developed and explained in this chapter, and used as a framework for analysis. The role of clusters is also described here.
- Chapter 6 draws out the conclusion, discusses the theoretical and practical implications, the limitations of the study, and makes suggestions for future work.

Chapter 2: Literature Review

There is an abundance of literature on the Indian software industry (see for example D'Costa and Sridharan, 2004) and software industries of other developing nations (for example, the entire issue of EJISDC, 2003). The literature that was reviewed covered such studies, especially those that discuss success factors and the role that the Government played. Two principal streams of literature emerged: studies that identified factors for success including Government (see for example Heeks and Nicholson, 2002), and studies that discussed the clustered nature of the industry and its consequent success (see for example Saxenian, 2002).

2.1 Literature on role of Government in the success of the software industry

Government has been listed as one of the possible factors behind the success of software industries alongside other factors such as demand and connection with international markets (Heeks and Nicholson, 2002; Bresnahan *et al.*, 2001), national vision and strategy (Porter, 1990; Tessler *et al.*, 2003), software industry characteristics (Arora *et al.*, 1999; Saxenian, 1994), domestic input factors/infrastructure including human capital (Fernandes, 2001; Oberoi, 1991; Arora *et al.*, 2000) and low entry barriers (Chandrashekhar, 2002). Tessler *et al.* (2003) identify the Government of India's role in building the Indian software industry as combining on-site labor with offshore outsourcing facilities, investing in telecom and computing infrastructure, and quality certification to establish credibility. Carmel (2003a) identifies Governments in general as being a factor in the success or failure of an industry, in addition to being *capable* of playing a proactive or facilitative role in seven other factors (Government vision and policy, human capital, quality of life, wages, industry characteristics such as clustering and specialization, capital, technology infrastructure, and ‘linkages’). On the other hand Wallsten (2001) studies some of the important factors such as public funding, Government subsidies, and establishment of technology infrastructure in the nature of ‘science parks’, and finds that although these are popular methods to catalyse industry clusters, there is no evidence of their ability to deliver industry success.

In Heeks’ (1996) seminal work on the role of the Government in India’s IT industry, he identifies their involvement as being one of “benign neglect”. Evans (1992, 1997) discusses the role of the government-state in promoting industry in general, and uses the Indian software industry as an example. Tessler *et al.* (2003) observes the role of Government as being two-pronged: to help create a domestic market, and (together with the private sector) to invest in education, infrastructure and other determinants. Kumar and Joseph (2004) identify the role of the ‘National Innovation System’ (NIS) in policy-making, infrastructure support and human resource creation, describing the need to see India’s success in the context of the 50-year role played by India’s National Innovation System.

Carmel (2003b) suggests that the export industry has a greater capacity for generating spillovers than the domestic industry and, as Hanna *et al.* (1995) and others also suggest, that the Government should focus on the domestic industry in order to develop backward linkages into the economy, as this will in turn improve the overall competitiveness of the industry (Schware, 1992; Porter, 1990). Joseph (2002) too discusses the need for Government to focus policy directives towards building the domestic market. Desai (2000) details the different carrots offered by the Government of India to its IT industry, and warns against this approach as being detrimental to economic stability.

Research that sought to explain the parallel success of industries in Israel and Ireland was also studied (see for example de Fontenay and Carmel, 2002; Green, 2000; Arora *et al.*, 2000; Crone, 2002; Tessler *et al.*, 2003). These cases were found to be quite different as the focus of these countries is on products and high-end services. The reasons attributed to the success of these industries also differed: the Government was seen to be a clear and proactive player with a number of clearly directed and supportive policies being implemented. In the case of Israel, funding and other forms of state support, mandatory military service and the country's strength in military research, the influx of Jewish immigrants (especially from the scientist-rich USSR), and linkages with the US market are seen to be key factors. In the case of Ireland, success factors included a Government campaign to dramatically increase Foreign Direct Investment (Irish companies captured 23% of all FDI projects in Europe in 1997, for instance), a huge increase in Government funding as part of its National Development Plan (2000-2006), and supportive policies designed over decades to develop its "knowledge economy" (in the context of EU membership) including investment in technology education.

2.2 Literature on success of the software industry as interpreted by Cluster Theory

Some researchers use cluster theories in offering an explanation for the success of the Indian software industry. Many cities around the world are evidence of the influence a particular location has in gravitating businesses operating in a specific industry towards it. There are two main theories that seek to explain this phenomenon: agglomeration, and clustering. Krugman (1991) is representative of the Marshallian (1920) view on agglomeration, and describes the formation of a cluster evolving around a historical "accident" that then gives way to self-reinforcing dynamics—the larger or more dynamic the cluster is, the larger and more dynamic it gets (the accident no longer playing its role) until other factors take over to limit its growth and/or dynamism (negative externalities arising due to congestion). Other reinforcing elements include supplier-consumer interactions leading to greater productivity, and all these are catalyzed by a relatively free flow of information between parties with various but related interests within the context of the ecosystem—industry, research centers and universities, and both formal and informal interaction between people (Romer, 1986; Saxenian, 1994).

Porter (1998) on the other hand, maintains that clusters are a key component of a region's comparative and/or competitive advantage and that for competitive advantage to be built and sustained, the five forces of factor conditions, local demand, related and supporting institutions, intensity of competition and national pride play a key role. Porter suggested that such clusters are the principal means by which advanced economies are able to create value. Geographical proximity amplifies the positive externalities between suppliers, consumers, and supporting industries. The special mechanics of a cluster ensure constant improvements in productivity. As Porter (1990, p149) says, "The phenomenon of clustering is so pervasive that it appears to be a central feature of advanced national economies".

Balasubramanyam and Balasubramanyam (2000), Streamlau (1996), Saxenian (2002) and Patni (1999) draw parallels between Silicon Valley and Bangalore, attributing the success of the Indian software industry chiefly to agglomeration economics. Yet, Tessler *et al.* (2003) note that "cluster-based initiatives should not be government-driven, but rather the result of market-friendly approaches."[3] Bresnahan *et al.* (2001) also find that "directive public-policy efforts to jump-start clusters or to make top-down or directive efforts to organize them" do not work, and that the right policies do have an element of "benign neglect" (Heeks, 1996).

While it is clear that the software industry in India does bear evidence to the adage "nothing succeeds like success", describing the phenomenon of a cluster, this raises some confusion about the role of Government in the success of the Indian software industry. One set of studies suggests that Government can play a positive role in creating the determinants for success, while largely ambivalent about the effectiveness of the Government of India. Another set of studies suggests a hands-off role for Governments to play, and even criticizes the efficacy of direct involvement. After

[3] Tessler *et al*. (2003) add the caveat that "Governments have discovered belatedly in Japan, Korea, Malaysia, and elsewhere, that neither government decree nor investment in real estate necessarily creates a cluster

all, cluster theory suggests that either a cluster emerges by accident (and then succeeds) or it emerges subsequent to the success of the industry. Did clusters in the Indian software industry emerge subsequent to its success, or alongside it? What was the role of the Government in this process?

This study draws out the role of the Government, demonstrating its part in creating clusters of excellence in the Indian software industry. Heeks and Nicholson (2002) point out that there is a difference between the initial and succeeding strategies for software industry development. Analogously, as discussed in Chapter 5, this study finds that the initial success factor was Government-induced cluster development, and the succeeding success factor was the natural dynamic of cluster reinforcement.

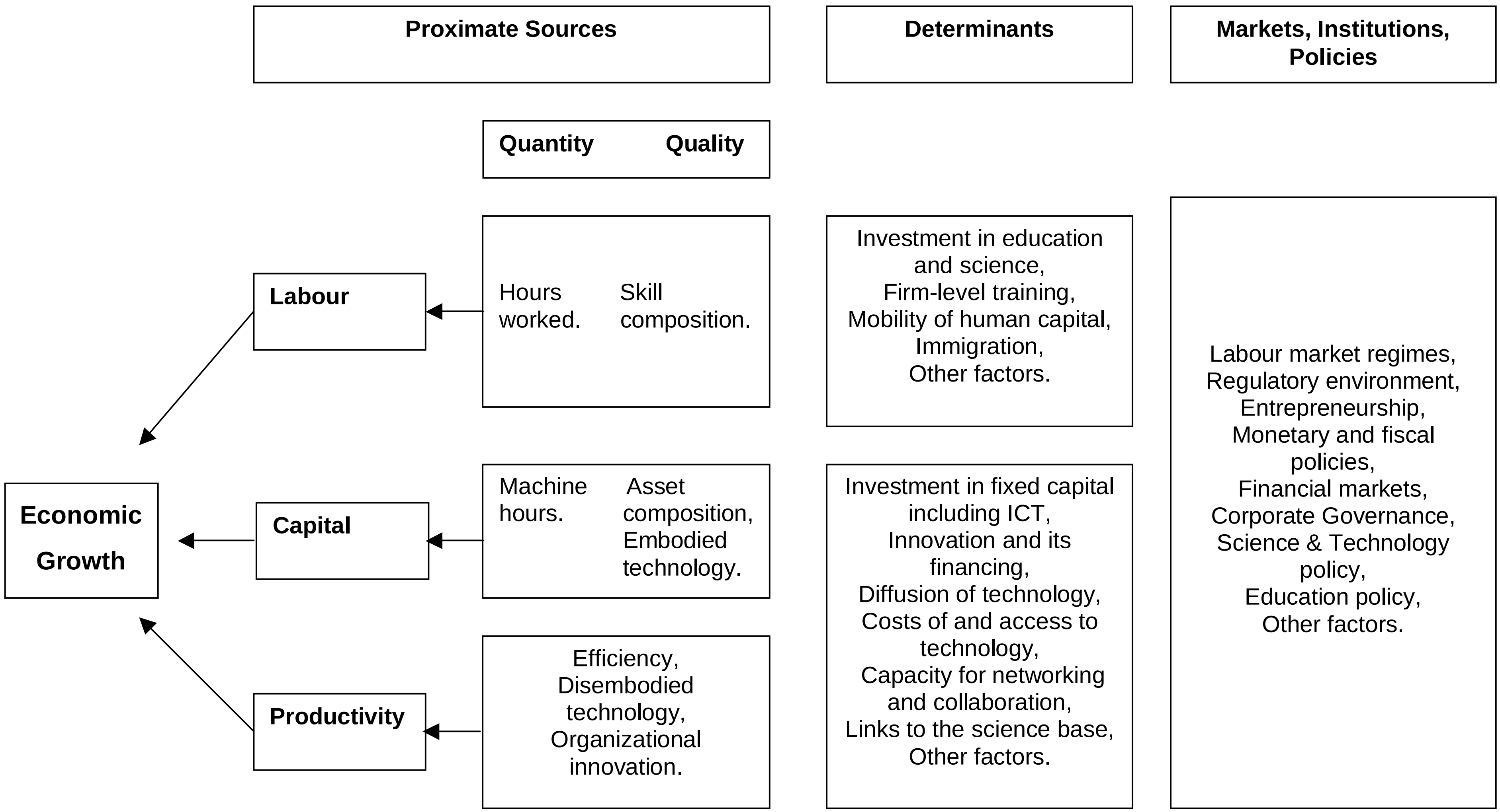
2.3 Selecting a model for "Role of Government"

Several models have been suggested in the literature to study the role of government and technology policy in the development and growth of technology industries. Under technology policy, King *et al.* (1992, 1994) include trade policy, foreign investment policy, and support for domestic industry, promotion of use, infrastructure development, and industry coordination as critical government roles. Ein-Dor *et al.* (1997*)* include government education policies, in addition to technology policies. In a study of role of government in technology development, (Wallsten 2001) focuses on public venture capital (direct governmental financial support) and science parks. de Fontenay and Carmel (2004) find Israel's success to be largely due to having "…had almost none of the government failures of developing countries…that would undermine its comparative advantage". In some Asian Tiger economies, for example Taiwan, governments, industry, and universities form a tightly coupled triad with funding and other forms of direct support from government (Dedrick and Kraemer, 2000; Liu, 2001). A similar arrangement is suggested in some European countries in the *triple-helix* model (Leydesdorff and Etzkowitz, 2001). These models were studied and found to be less suitable for the context of this study.

Figure 1 shows the model used in this thesis, adopted from the analytical framework of OECD to study ‘new economy’ growth and its causes, particularly innovation in ICT (OECD, 2000). The study examines the role of innovation in information and communications technologies in recent OECD growth performance. The framework consists of three parts: (1) “Proximate” sources of growth (competitiveness) such as labor, capital, and productivity (2) Determinants (critical success factors) of growth; and (3) Impact of institutional factors (policies) on the determinants of growth.

While the model was developed to address an economy as a whole, we have adopted it in our study of one industry within the economy. The model was selected because of its fit with the context (role of government), and the model itself was found to be consistent with our independent conclusions through interviews and secondary data. This study discusses the role of the Government in driving the determinants (and therefore the proximate sources which result in industry success or failure).

Figure 1: OECD Model on role of innovation in ICT in economic growth performance



Source: OECD, 2000

Chapter 3: Methodology

3.1 Details of research method

The case study methodology was adopted in this study. According to Winegardner (2001), the end product of a qualitative research process is a document that is “richly descriptive” with “words and pictures rather than numbers”. Interviews were open-ended with minimal structure, and were conducted over 2001-2004. Initial interviews suggested a positive role played by the Government, and this then became the focal point of subsequent interviews. Certain key interviewees were interviewed more than once, as the study progressed. The data was then aggregated and analyzed, and the findings were subject to review by key interviewees (Yin, 1984, 1993; Myers, 1997; Strauss and Corbin, 1998).

The overall research strategy could be categorized as interpretivist; guided by the knowledge of reality as socially constructed by individual human actors (Walsham, 1995). An interpretivist approach tries to understand the perspective of different actors in a situation, without trying to give the status of "truth" to one interpretation over another. Instead, the approach was to try to understand the multiple perspectives presented, and to understand why the interpretation of one person differed from another's on similar issues (e.g.; the impact of Government-funded ‘marketing trips’ to Europe).

Initially, a series of interviews were conducted with professionals within the industry who have been involved since its inception. The background of the study was introduced as investigating reasons behind the success of the industry, the word ‘success’ being open for discussion during the interview. This ensured that these initial interviews stayed open-ended. A variety of reasons were drawn out, and these largely corroborated with existing discussions in the literature. When questioned on the importance and nature of the role of Government, each interviewee had a unique opinion and anecdotal evidence to support that opinion. This made role of Government an interesting aspect to explore further into.

Prior to the next set of interviews, secondary research was conducted on the role of Government in the Indian software industry. This consisted of reading various trade journals, research articles, newspaper clippings, magazines, NASSCOM reports, Government documents, and online articles/commentaries. The key Government departments involved were the DoE and the IT departments in each state. The Secretary of the department is the person who has a holistic view of all the intentions and actions of that department, during his/her time in office, and hence, two former Secretaries from the Department of Electronics (Central Government function) and the IT Secretary (for the State of Andhra Pradesh) were interviewed. Since several interviewees indicated that the Indian Railways computerization project played an important role in the growth of the software industry, the then General Manager of the Railways (South) was included in the list of interviewees.

As the study progressed, it became clear that human capital was seen as a critical success factor for the industry, and also that the Government had played a significant role here. In order to verify this, eminent academicians in the Science and Technology areas, as well as individuals who played a part in the drafting of Science and Technology education policies were interviewed. In addition, the Directors of various institutions for technological education were interviewed for ‘insider views’ on the supply and demand dynamics of human capital for the software industry.

From the industry, interviewees were selected based on the status of the company within the industry (e.g. Infosys is seen as a pioneer), their contribution to the industry (e.g. as an industry forum leader), their unique perspective of the industry (e.g. firm specializing in recruitment for software companies), and their orientation (e.g. both product and service companies). Only CEO/board-level professionals were considered, as the likelihood that they would have a holistic view of the industry is higher. With the industry professionals, interviewees usually assisted us in identifying other individuals who they felt would have relevant insights and experiences to share.

For example, Mr. Narayanmurthy (Chairman, Infosys) introduced us to Mr. Vittal (Secretary, DoE) to learn more about the role of Government during his tenure.

For independent companies the starting-up phase and subsequent phases in the growth of companies were considered. For the other companies, the various stages of movement up the value chain were discussed, particularly events that gave impetus to these changes. Interviews started with the origin and background of the interviewees, the conditions in which they selected (or found themselves in) the software industry, their educational and professional experience up until that point, and their initial and subsequent strategies as far as their company/institution/body was concerned. The role of the Government, if any, was considered throughout the interview.

I carefully documented my thoughts and reflections in relation to the case and related findings to the conceptual framework (Baskerville & Wood-Harper, 1998). Interviews were conducted largely in English, usually at the office of the interviewee (though sometimes in cafes and restaurants), and typically lasted for two to three hours. Notes were made during the meetings, and these were reviewed as soon as possible afterwards, and interpretations were refined. Follow-up phone calls were made in some cases to clarify certain points.

The guidelines for conducting and evaluating an interpretive study are well described in Klein and Myers (1999), who list seven principles, and I discuss these next.

As a researcher, I have a preference for the development and harmonization of concepts, rather than empirical verification. I have a strong preference for the human side of the story, and to introduce or integrate multiple perspectives. I prefer to argue why a particular hypothesis ought to be considered, rather than seeking to test a particular hypothesis. This makes my work vulnerable to criticism from a positivist standpoint, as it is not statistically robust. I view the richness and broadness of perspective that such a study brings as being its key strength.

The principle of the hermeneutic circle is very much prevalent in my study, in the attempt to bring clarity to the context through repeated, iterative, examinations of both the parts (analyses of interviews and data) and the whole (the software industry). In particular, the process of resolving the different opinions expressed by interviewees, the wealth of prior research on the topic, and my own analysis, proved to be particularly iterative. The hermeneutic cycle, as Klein and Myers (1999), describe, is indeed applied at each and every step along the way, and incorporates every other principle.

My understanding of (us) Indians is that we are not prone to flattering our Government. As an Indian discussing the subject with other Indians, I found the discussion often veering towards a general criticism of the Government. Keeping in mind the principle of suspicion, I remained cautious of this in my interviews, since opportunities to criticize the Government are rampant. Yet, being excessively focused can cause certain relevant facts to remain hidden and not come to light. The dynamics in the interactions between the interviewees (subjects) and I (researcher) have an impact on both the data (interviews) as well as the interpretation (analysis). After all, the interviewees themselves were participants in the growth of the software industry, and experienced the changes within their specific context as experienced from their perspective on life, and they recount their experiences through the stained glass of memory. It was useful to question opinions expressed by interviewees, and ask for factual or anecdotal evidence to support their convictions. In the course of conducting my interviews, I realized that to draw out the truth, the interviewer requires not just the intellectual rigor of a scientist, but also the open-mindedness of an artist and the patience of a saint.

The background of the case is described in detail in Chapter 4, adhering to the principle of contextualization. In terms of role of Government, the study discusses both the role played in the incipient stages of the industry and the role the Government now plays. Since the subject concerns the success of the industry, the study focuses on the earlier years, when decisions had maximum impact. In a way the entire study is one of contextualization—putting the role of the Government in the context of the subsequent success of the industry.

The principle of interactions between the researchers and the subjects, as well as the principal of dialogical reasoning was fundamental to this study. My initial sense from my personal knowledge framework (having grown up in India, and being co-founder of a multinational company with a software development centre in Bangalore, India) was that the Government role was one of benign neglect (at best). This was supported by my initial study of the literature available on the subject. When I embarked on this study, I wasn't certain what the reasons for the success of the industry were, and while I could suggest a few factors, Government did not figure strongly as one of them. As the study progressed, particularly the interviews, I had to question this preconception. It became evident from interviewees, many of whom have been in the industry since its inception, that the Government perhaps had more to do with the industry's success than I was initially willing to concede. Having to negotiate through contrasting facts and differences of opinions, while influencing and being influenced by the interviewees, led me to a richer understanding of the industry. The study highlights the constructive actions of the Government of India in building the country's software industry. Since the contrasting view is that the Government did nothing ("benign neglect"), there is not very much to discuss in terms of dialogical reasoning in this specific sense.

The principle of multiple interpretations is particularly clear in this case. The Government has traditionally been seen in its role as inhibitor to success rather than facilitator, and as the study progressed, there were a multitude of different perspectives, both factual and anecdotal, that led to multiple possible interpretations. In a case as controversial as this, one almost runs a risk in drawing *any* conclusion. The key point I kept in mind is that one is required to have *sensitivity* to multiple interpretations, and that it is entirely possible to draw a conclusion that may not be consistent with one or more interpretations, and yet includes them in the analysis. As part of the hermeneutic cycle, I visited key interviewees more than once during the course of the study. At times, an interviewee shared a perspective on a certain aspect of the industry, and at other times the same interviewee shared a different perspective on the same aspect. In all likelihood, this was also due to my understanding of the subject evolving as the study progressed.

In studying the role of Government in the success of the industry, the cluster/agglomeration theory kept arising, which led me to study the literature on cluster theory and to search for an appropriate framework (discussed in Chapter 2). I felt it vital to harmonize these frameworks. Doing so has, I believe, led to an important abstraction: that Governments do have a role to play in cluster formation. The study provides an example of a new way in which the OECD (2000) model for economic development can be used, and this is a useful theoretical contribution.

Chapter 4: Case Description and Analysis

This chapter is an outcome of my research; based on secondary sources including journal articles, trade magazines, industry websites, newspaper articles, and books on the subject; as well as on interviews conducted between 2001-2004. The purpose of this chapter is to give an overview of India as well as a detailed background of its software industry. As such, this chapter is a contribution of this thesis, in terms of an updated description of the state of the industry. Figure 8 in this chapter, the "Value Pyramid", represents another contribution of this thesis, illustrating the competency of Indian firms at different points along the value chain.

4.1 The Country

4.1.1 DEMOGRAPHICS

India is a large, diverse and under-developed country with a bureaucratic and corrupt Government, ranked 90th out of 146 countries (Roy, 2005). Home to 16% of the world's total population, it occupies just 2.42% of the world's total land area. As of 2005, approximately 39% of its adult population (over the age of 15) is illiterate (UNESCO Institute for Statistics, 2005). Fragmentation exists at many levels: the country is divided into 28 states and 7 union territories (Figure 2), over 1027 million people (2001 census) are spread over 3.3 million square kilometers, speak 18 major languages with 844 dialects, and practice Hinduism, Islam, Christianity, Buddhism, Sikhis, Jainism, Judaism, Zoroastrianism amongst a host of other lesser-known religions[4]. The

[4] http://www.indianembassy.org/dydemo/indiaprofile/profile.htm

success of the country's software industry is all the more surprising given its fragmented, diverse, nature.

Figure 2: Map of India

Source: http://www.mapsofindia.com

4.1.2 COMPLEX SYSTEM OF GOVERNANCE

The political climate in India is characterized by instability. Although the term of Government is 5 years, this is rarely the case. India had six-month governments, three-month governments and at one point, even a two-week government[5]. There have been seventeen governments in the past fifty years, an average of less than three years each. Apart from the first government (1947-1964) led by Jawaharlal Nehru, the average life of the government has been two years and four months before they are forced to resign.

The system of government in the states closely resembles that of the Union. The State Executive consists of the Governor and a Council of Ministers with the Chief Minister at its head. The President appoints the Governor of the State for a term of five years. The Governor functions as a figurehead, similar to the President. The Council of Ministers is responsible to the Legislative Assembly of the state, which consists of the Governor and one House or two Houses. It is a complex system of governance! India recently completed its general elections to elect its 14th Lok Sabha. At the 2004 general elections, there were 7 National parties and 55 State parties. These parties are ambiguously and complexly inter-twined. A true democracy; people of foreign origin, bus conductors, movie stars and bandit queens figure prominently in Indian politics.

It must be noted that at each and every one of these levels, the parties in power may be, and consistently are, different. Indeed even at a particular level it is seldom that any one party holds majority, it is usually a fragile alliance of two or more parties ("coalition governments"). The last two governments have been coalition governments with no single party succeeding in getting a simple majority. The newly formed Government includes parties that aligned themselves to the present Opposition during their rule in the previous term. With the current Government being supported by the Left, differences over economic policy have already begun to emerge. Due to this fragility, governments at the Centre and many states are inherently unstable. This limits the desirability for long-term strategic improvements to the nation, and encourages short-term vote-pulling measures. Infused with different agendas, new governments often steer in tangents to the paths treaded by previous governments.

---

[5] Atal Bihari Vajpayee's Government: 16 May 1996 - 01 June 1996

Each of these many layers of government has its own sphere of power and responsibilities, and interference between layers is restricted by the Constitution. Thus, cohesiveness of national purpose and synergy of undertakings is difficult to achieve and India lags well behind countries with more stable governments, such as The Peoples' Republic of China, in most development indexes (Table 1), per capita GDP and importance of high-technology exports. Yet, India's software industry is far more developed than is China's (Business Week, 2005; Saran, 2005; The Economist, 2005), and this raises interesting questions about role of Government.

Table 1: India and China: A comparison (2003)

Indicator	Unit	India	China
Population	Million	1064.4	1288.4
Birth rate	Per 1000	24	15
Death rate	Per 1000	8	8
Infant mortality rate	Per 1000 live births	63	30
Life expectancy at birth	Years	63.42	70.8
Adult literacy rate (2005, estimate*)	%	61.1	90.9
Internet users	Per 1000 people	17.49	63.25
Fixed line and mobile phone subscribers	Per 1000 people	71.03	423.8
Foreign direct investment, net inflows	US$	4,269,000,000	53,504,999,424
GDP growth	Annual %	8.61	9.3
GNI per capita, Atlas method	US$	540	1100
High-technology exports	As a % of manufactured exports	4.75	27.1

Source: World Development Indicators Database, 2005; UNESCO Institute for Statistics (UIS), 2005.

* Literacy statistics were found to vary depending on the source. The figures chosen are the national estimates provided in 2005, and approved by the UIS. These figures more-or-less tally with UNESCO projections based on the last available surveys (pre-2000).

4.2 The industry

4.2.1 OVERVIEW

A World Bank funded study conducted over a decade ago (World Bank, 1992) to discuss Indian software strategies identified that companies in the US preferred to get their software developed in India for its high quality and relatively low cost advantage. Fourteen years later, this remains unaltered. As of 2004, more than 255 of the *Fortune 500* companies were outsourcing their software development requirements to India (NASSCOM), both for the cost benefit and for the quality. While the cost benefits are clearly understood, it must be noted that by this time, 66 Indian companies had the unique distinction of being certified at the SEI-CMM Level 5—this out of a total of about 150 organizations worldwide[6]. The Indian software industry has achieved a remarkable rate of progress from its beginnings in the 1960's. Table 2 indicates the growth in software exports between 1990 and 2004.

Table 2: Growth of Software Exports (1990-2004)

Year	**Software Exports (US$m)**	**Growth Rate**
1990-1991	131.2	51%
1991-1992	173.9	33%
1992-1993	219.8	26%
1993-1994	314.0	43%
1994-1995	480.9	53%
1995-1996	734	52%
1996-1997	1083	48%
1997-1998	1750	62%
1998-1999	2650	52%
1999-2000	4000	51%
2000-2001	6200	55%
2001-2002	7650	24%
2002-2003	9545	29%
2003-2004	12500	31%

Source: NASSCOM; Patibandla *et al*., 2000; Arora *et al.,* 1999; Heeks, 1998.

6 http://www.nasscom.org/artdisplay.asp?Art_id=3212 accessed on March 12, 2005.

The software export industry contributes almost 20% of India's total exports. Compared to the 50% compounded annual growth rate of the software industry, the growth rate of the Indian industry sector is 7.6%, while the Indian service sector has a growth rate of 8.2%. Table 3 shows the ranking of software companies in terms of export revenues.

Table 3: Ranking of Software Companies (pre-2001) by export revenue

Rank	**1980-81**	**1985-86**	**1989-90**	**1994-95**	**1997-98**	**2000-01**
1	TCS	TCS	TCS	TCS	TCS	TCS
2	TUL	TUL	TUL	TUL	Wipro	Infosys
3	Computronics	PCS	COSL	Wipro	Tata Infotech	Wipro
4	Shaw Wallace	Hinditron	Datamatics	Pentafour	Pentafour	Satyam
5	Hinditron	Infosys	Texas Instruments	Infosys	Infosys	HCL
6	Indicos Systems	Datamatics	Digital (DEIL)	Silverline	Satyam	Cognizant
7	ORG	DCM DP	PCS	Fujitsu	Tata IBM	SilverLine
8	System	COSL	Mahindra-BT	Digital (DEIL)	CMC Ltd	NIIT

Source: NASSCOM

4.2.2 IT IS A SERVICE INDUSTRY

The Indian software industry is heavily service oriented. One of the reasons offered for the large growth rates associated with the Indian software industry has been its orientation towards low-end software services as opposed to products and packages. The "Year 2000 problem" resulted in an explosion of services work outsourced to India (cumulative worth of $2 billion, according to some sources). This has led to the opinion that Y2K services were one of the major drivers of the software industry in India. Heeks (1998) for example, points out that "the Year 2000 problem… …now estimated to make up nearly 40% of current software export work from India." According to a NASSCOM survey during 1999-2000 however, solutions for Y2K revenues accounted for just about 12 per cent of India's software export. While revenues from export of Y2K software solutions were worth US$ 480 million out a of total Indian software exports of US$ 4 billion during this period, post-Y2K, the year 2000-2001 recorded a growth of 55% in software exports with no reliance on Y2K services. The period did however increase the visibility of the Indian software industry and provide an opportunity for firms to 'get their feet wet' with outsourcing. Table 4 lists the revenue position of the top 15 companies in 2001 and in 2004, while Table 5 gives a breakdown of software export revenue by type.

Table 4: The top 15 Indian software companies, by revenue[7]

Company	Rank 2004	Exports in 2001 (US$m)	Exports in 2004 (US$m)
Tata Consultancy Services (TCS)	1	617.6	1198.9
Infosys Technologies Ltd	2	411.5	1026.0
Wipro Technologies	3	390.2	854.1
Satyam Computer Service ltd	4	275.6	538.6
HCL Technologies Ltd	5	250.4	412.9
Patni Computer Systems Ltd	6	114.5	266.4
IFlex Solutions	7	65.11	168.4
Mahindra British Telecom Ltd	8	99.7	158.5
Polaris Software	9	-	126.1
Perot Systems TSI (HCL)	10	97.5	118.6
Digital Globalsoft Ltd	11	-	117.9
NIIT Ltd	12	126.6	117.2
iGate Global Solutions Limited	13	75.5	106.4
Birlasoft Ltd	14	-	93.1
Mphasis BFL Ltd	15	62.95	85.5

Source: NASSCOM

[7] Note: This list does not include companies, such as Cognizant, which are US-listed but have significant offshore operations in India. In 2003-04 for instance, Cognizant recorded revenues that would place them 6th on this list were they to be ranked.

Table 5: Breakdown of Indian Software Exports by Type

<table>
<tr><th>Type</th><th>Late 1980s %</th><th>1990’s %</th></tr>
<tr><td>Sales of Software packages</td><td>1-2</td><td>2-5</td></tr>
<tr><td>Digitization and Data entry</td><td>< 1</td><td>2-4</td></tr>
<tr><td>Customized conversion work</td><td>20-40</td><td rowspan="2">95</td></tr>
<tr><td>Custom application building</td><td>60-80</td></tr>
</table>

Source: Heeks, 1996; NASSCOM

Interviewees identified some of the key differences between services and products in the software industry to be:

1. Products have long term revenue potential while services are billed project by project.
2. Products have a wider base while services are aimed at a single client/set of clients.
3. Products have only a 1 - 5% chance of success; hence risk is part of product development.

Several interviewees were of the opinion that the greater concentration on services as opposed to packages is a result of Indian companies lacking the ability to excel in the marketing arena. However, one interviewee pointed out that Indians are “not only the top men in technology firms but also in marketing firms”, and was of the opinion that what Indian companies lack is not ‘marketing skills’ but ‘marketing guts’, suggesting that risk-averseness is a characteristic Indian trait. Other suggested reasons for this concentration on services are (Interviews) an under-developed local market resulting in inexperience in product development, an unfamiliarity with foreign markets fortified by the difficulty to keep up with changing needs and standards due to the distance from global markets, insufficient capital to venture into product creation and marketing let alone support, maintenance and upgrades, and lack of reputation as a software package source. The importance of PR and branding seem to be lost on the Indian software industry as well. An insightful suggestion was that the Indian middle-class is not entrepreneurial and software graduates (typically middle-class Indians) lacked the gumption to have a “go at it” preferring instead to join large companies like the SUN Microsystems and Hewlett-Packards of the world rather than software startups.

Firms in India sometimes seek to establish a partnership where the Indian company manufactures the product according to specifications supplied by the foreign collaborator who subsequently markets the product in the foreign market (Interviews). Often, the firms agree to undertake software development for the foreign firm, with the implicit agreement that they will try to develop the subsequent solution into a product for that niche. This form of software development is usually the first (and almost always, the last) step towards product development. For example, Aditi Technologies (headquartered in Bangalore) worked on projects for companies like Citicorp and Sony, and developed a CRM solution that they turned into a 'product' called Tasmay. Tasmay was subsequently spun off as a separate entity[8]. However, the 'services' mentality is harder to spin off; and today the company provides services that leverage on the developed platform. The go-to-market approach is thus altogether different from a pure software product player. Other examples of similar systems are TCS's Casepac (Heeks, 1996) and Infosys's Yantra (an ERP solution which was spun off as a separate company[9]). These are often referred to as "semi-packaged software". Thus, the figure of "2-5%" in Table 5 does not actually refer to shrink-wrapped products, but to semi-packaged software. The actual figure for products in the late 1990's was probably closer to 1-2% (Interviews), and today the figure may be closer to the 5% mentioned, than it was then (World Bank, 1995). Apte (1988) attributes this to an absence of public policy, and a poor ability to commercially exploit the quality research work done in the public sector.

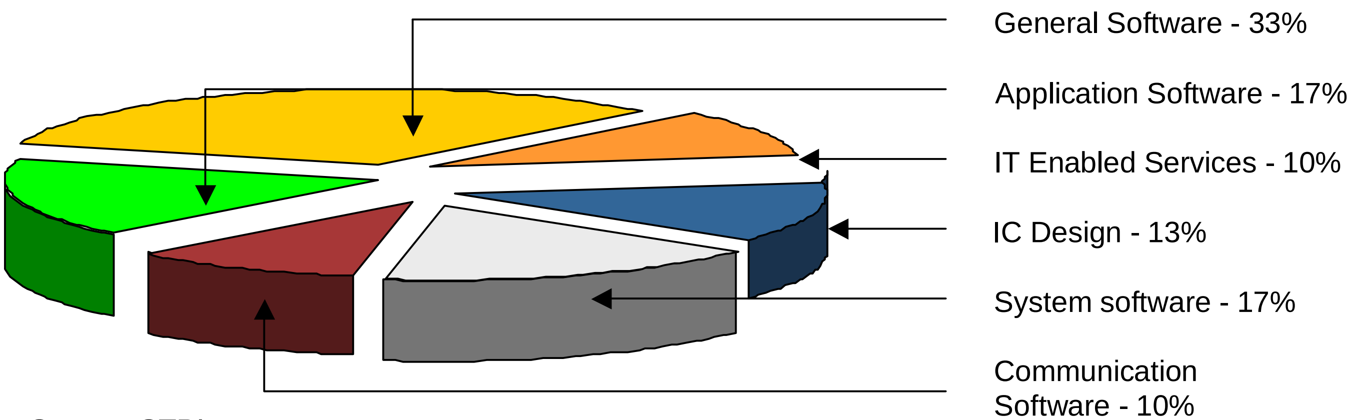
Nevertheless there are remarkable exceptions to this, such as the work done by embedded systems companies such as Encore solutions[10], whose work in Digital Signal Processing (DSP) technologies is recognized worldwide. Companies are beginning to realize the advantage of a product-oriented offering as against a service-oriented offering: that income is not directly correlated to manpower and "Time and Materials", but that "revenue is potentially infinite" (Interview). Still, few Indian companies have ventured into products as the statistics indicate, and

---

[8] Interviews, http://www.aditi.com/Homelinks/productdev.htm
[9] Interviews, www.yantra.com
[10] www.ncoretech.com

the bulk of the Indian companies in services are in lower-end services. Figure 3 shows the composition of the Indian software service industry, in 2004, by type of software.

Figure 3: Industry Composition in 2004



Source: STPI

India's major reliance on software service exports has caused India a competitive disadvantage in the global market (from a revenue perspective) compared to countries where the industry relies less on export of software services and more on export of software products (Chakraborty and Dutta, 2002).

4.2.3 IT IS AN EXPORT-ORIENTED INDUSTRY

The late Dewang Mehta, former President of NASSCOM, said, "India will do to software what Japan did to the car". Japan's automobile industry had its foundations in a strong and intensely competitive local market that was protected by the Government from foreign entrants. Outgrowing the local market, these companies moved abroad. As we shall see later, the Indian Government too created a protectionist environment within the country, stimulated software production, and aggressively directed firms towards the export market. Software export has always been the predominant focus of the industry, both from the point of view of government policy-making and the proclivity of the players. Mukhi and Chellam (1988) identified that “for several years now the Indian government has been dreaming about Indian software exports overtaking all other commodity exports in the service sector”. Table 6 shows the breakdown of software production between domestic and export markets.

Table 6: Breakdown of Software Production: Domestic and Export (US$ million)

Year	**‘95-‘96**	**‘97-‘98**	**‘99-2000**	**2000-‘01**	**2001-‘02**	**2002-‘03**	**2003-‘04**
Domestic	390	950	1,700	2,400	2,310	2,600	3,400
Export	734	1,750	4,000	6,200	7,650	9,545	12,500
Total	1,124	2,700	5,700	8,600	9,960	12,475	15,900
Domestic/Total	34.7%	35.2%	29.8%	27.9%	23.2%	20.8%	21.4%
Export/Total	63.4%	64.8%	70.2%	72.1%	76.8%	79.2%	78.6%
Export/Domestic	188%	184%	235%	271%	331%	380%	367%

Sources: NASSCOM; Patibandla *et al.*, 2000

In fact, while India’s share of the global software market for products and service is undoubtedly low (Bajpai and Shastri, 1998, put this number at 0.5%), it enjoys a share reported to be as high as 18.2% of the global cross-country customized software market (Tschang, 2001). India’s software industry has traditionally been export-oriented. In 1986 there were 50 companies involved in export, in 1990 there were 140 such companies (Oberoi and Raghunathan, 1991), in 1998 there were 716 export companies, 860 in 1999 (Iwami, 2000) and is currently at over 3,000 (NASSCOM). While Ghemawat and Patibandla (1999) characterize the export industry as an “island of competitiveness” and Kohli (1989) says, “There has been an overemphasis on exports rather than on building an industry which could meet both internal demands as well as export requirements”, these ignore the actual contribution of the industry and the remarkable fact that *despite* not having a strong domestic market, the industry has been a successful exporter. Heeks

(1996) quotes an interviewee, “One illusion we must remove from our mind. No industry can really export unless you develop a domestic market. If you don’t develop a strong domestic software market, how do you expect to export?” However this is not the case for a service-oriented industry where skills rather than products are for sale.

On one hand, researchers such as Heeks (1996) and Balasubramaniam and Balasubramaniam (1997) argue that although the weakness of the domestic market in India was one of the major reasons for driving companies into the export market, linkages with the domestic market reduce weaknesses and improve credibility, skills, product innovation and market understanding. On the other hand, researchers such as Ghemawat and Patibandla (1999) suggest that “internationally competitive industries in poor countries are more likely to emerge as industries characterized by relatively weak inter-industry linkages rather than strong ones; thus strong linkages with other domestic industries within an under-developed and generally uncompetitive domestic context are more likely to drag down international competitiveness than to increase it”. Our interviews suggested that these analyses are constructed within a product-framework rather than a service-framework. When the primary resource is human capital as a factor of production, and the emphasis on production rather than innovation, the issue of domestic market linkages does not arise.

The US is the dominant destination for India’s software exports. As the largest consumer of software in the world (by far), and characterized by a competitive domestic market, the US has a great demand for technically skilled personnel and is a major customer for outsourcing. Heeks (1998) mentions that Indian companies have exported software to more than 40 countries, but that there is a heavy reliance on the US Market. In 1999-2000, software was exported to 95 countries around the world and in 2000-01, the number of countries that Indian companies exported software to increased to 102. The distribution chiefly migrated towards a greater concentration on USA and Europe. With the large number of Non Resident Indians returning to India and setting up companies here to address demand in the country they are returning from, the export nature of the industry has further developed. With the growth of ITES and BPO, India's software exports to the US increased in 2002-03. Of India's ITES/BPO exports, 80-85% are to the US (NASSCOM). 2004 saw the popularity of business process outsourcing (BPO) growing exponentially. Table 7 shows the main markets that India exports software to, while Table 8 contrasts the IT services spending of these different markets with India's share.

Table 7: Destinations of Software Export

Destination Region	**Proportion of Total Software Exports (%)**			
	1980's-1990's	1997-98	1999-2000	2000-2001
USA	60-65	58	62	62
Europe	20	21	23.5	24
Japan	0-3	4	3.5	4
Australia & New Zealand	5-10	2	1.5	10
SE Asia	5-10	6	3.5	
West Asia		2	1.5	
Rest of the World		7	4.5	
Total	100	100	100	100

Source: Heeks (1996); NASSCOM; Arora *et al.* (1999)

Table 8: IT Services Spending: Regional Shares 2002-2003

Region	**IT Services spending (US$bn)**	**India's exports (US$mn)**	**India's market share (%)**	**Share in India's exports (%)**
North America	171.1	6,462	3.78%	67.7
Western Europe	109.6	2,033	1.85%	21.3
Japan	34.9	186.6	0.53%	2
Latin America & Rest of the World	17.5	563.5	3.22%	5.9
Asia Pacific	16	300.6	1.88%	3.2

Source: NASSCOM

Table 7 and Table 8 indicate that there has been no significant historical variation in destinations of export by the Indian software industry. Attempting to change this reliance on the US, the government encourages software export to European countries such as the Netherlands and Italy. For instance, they offer a refund of 15% of travel expenses for marketing trips to European countries, in a bid to veer smaller players in the industry away from the US. 80% of Indian software exports are to the six OECD countries that account for 71% of the worldwide software market: USA, UK, Japan, France, Germany and Italy (NASSCOM).

In addition to the US being the largest software market in the world, American firms moved far quicker than the Europeans in taking advantage of offshore programming (Heeks, 1998). In addition, the US has had more liberal rules of employment and immigration historically[11]. India is "more locked-in to the US market than others because many Indian businesses have links through family members or friends who are US residents" (Heeks, 1998). This is a self-perpetuating cycle. Even as the share of the US market for software is diminishing as trade becomes increasingly global and as worldwide, economy shifts towards an emphasis on knowledge as opposed to capital, the US market is still growing in absolute terms. While new markets (particularly in Europe) are being actively explored, the trend of a US-oriented market for Indian software export is expected to continue for the next 4-5 years (NASSCOM).

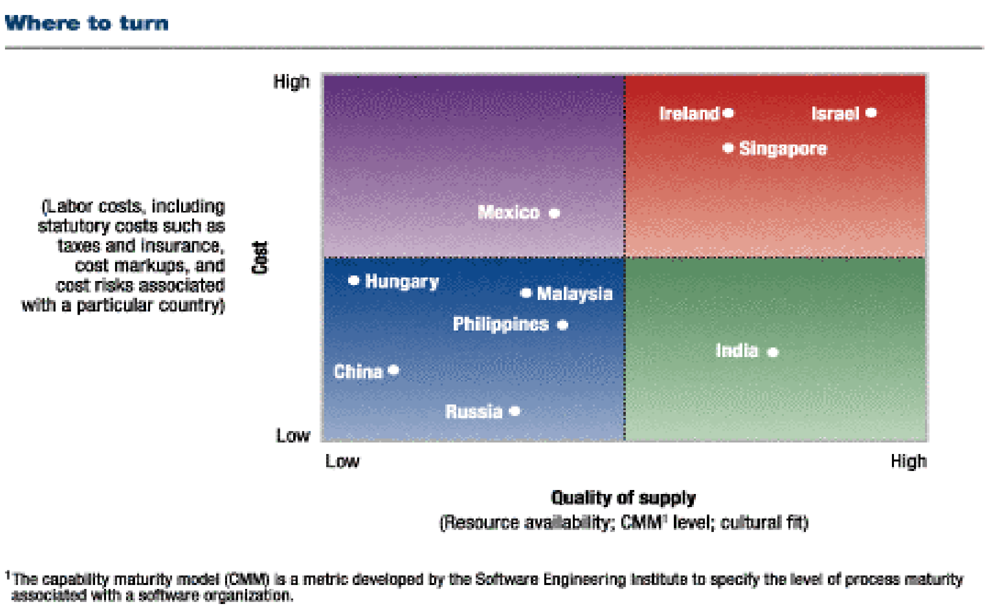
4.2.4 LOW IN COST AND HIGH IN QUALITY

India has become a popular outsourcing destination for many major players in the global software market. What is more remarkable than a growth that hovers around 50% is the fact that this growth is sustained year after year. Some of the reasons that have been offered for the

[11] An H1B visa allows a foreigner with technical skills and a job offer from a U.S.-based company to work in the United States for three to six years. Sunil Mehta of NASSCOM indicates that approximately 40% of H1B visas issued by the United States are to Indians (Excerpt from interview on http://www.namasthenri.com/snippets/150203b.htm, last accessed 6th December 2005).

remarkable sustenance of this high growth (Heeks, 1996; Arora *et al.*, 1999; Fernandes, 2001; Interviews) are that labor is available at low cost in India while a high quality of work is maintained. Figure 4 shows a comparison between countries in terms of cost and quality of labor.

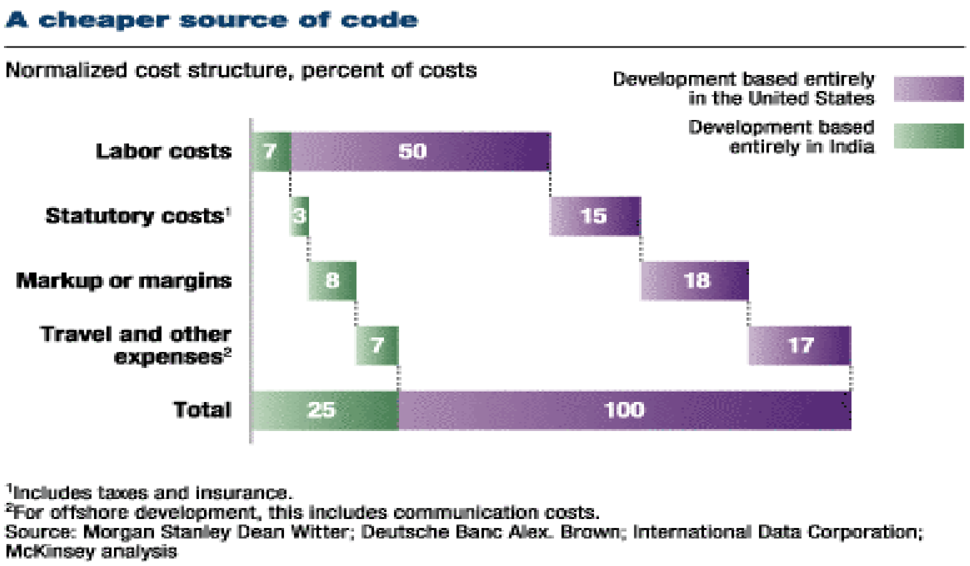
Figure 4: Cost and Quality comparison



Source: McKinsey (2001)

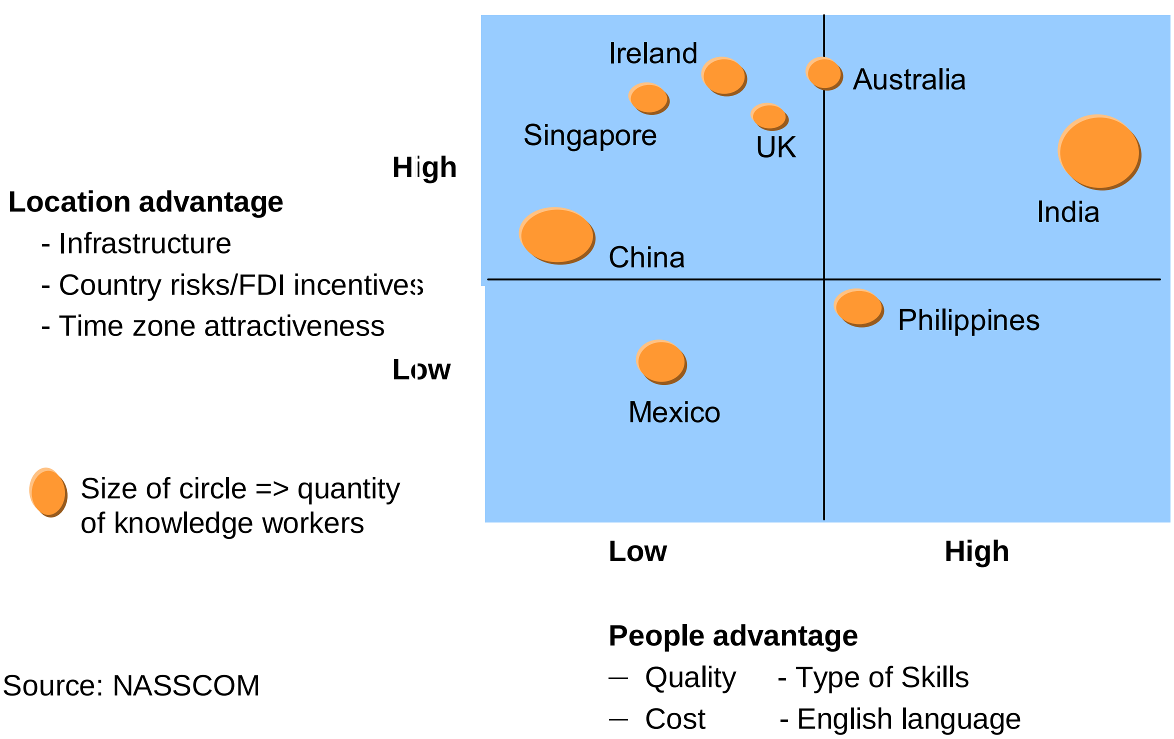
There is a huge pool of English-speaking technically skilled workers and a major advantage, especially to the BPO industry, is a 12-hour time difference with the US. Figure 5 shows the cost savings due to off-shoring development work, and Figure 6 highlights the competitiveness of the industry as identified in the NASSCOM-McKinsey report of 2002, which studied the Indian software industry and identified strategic initiatives to ensure its sustained growth. It found that companies value the flexible nature of Indian professionals and the ability of the Indian company to assemble functional teams of engineers at very short notice. The parallel growth in the software outsourcing market was also seen to contribute to the growth of the Indian software industry.

Figure 5: Cost difference breakdown



Source: McKinsey (2001)

Figure 6: India's position in Global Software Outsourcing Market



Source: NASSCOM

4.2.5. PEOPLE ARE 'EXPORTED' IN ADDITION TO SERVICES

There are three approaches that Indian companies take in exporting software. The first is pure onsite work, or labor augmentation, where the company supplies the foreign client with the requisite skilled labor. The client is responsible for work allocation and project management in this case. A second approach is to combine onsite and offshore work in varying proportions. Offshore work is far more cost effective: as much as 25-30% below the cost of the same job undertaken onsite (Arora *et al.,* 1999). Two of the main restraints to conducting work offshore are trust in the capabilities of the company that the task is being outsourced to, and the issue of face-to-face communication being necessary (Arora *et al.*, 1999). Typically the Indian company sends a team of software engineers to understand the client's requirements and development is carried out offshore, in India. Sometimes members of the team may reside in the client's location in order to facilitate specifications confirmation and to reassure the client that the project is going on course and that requirements are clearly understood. This is more important than may seem evident, as one of the common complaints about Indian software companies by foreign clients is that they feel the existence of a fence between them: the clients are used to an interactive exchange of viewpoints on requirements analysis and problem complexities, whereas Indians are said to be silent through much of the process, to the discomfort of the clients who are unsure if their communication is effective (Interviews[12]).

Indian software exporters used to start by venturing into low-skilled onsite programming. This has been labeled with the derogatory term "body-shopping", and such companies were said to be "glorified employment agencies" (Interviews). The past 10 years has seen the emergence of "on-line labor" (Aneesh, 2000) as programming has steadily shifted offshore. The shortage of analysts and the expense associated with traditional onsite work has led to a migration of experienced analysts to the foreign country, and the offshore outsourcing of work to local

[12] One interviewee likened this to throwing a package over a high wall, unsure of whether the person on the other side has caught it; in fact unsure if there is indeed another person on that side of the wall!

companies. In 1988, the ratio of onsite to offshore work was in the region of 65:35. Software is particularly conducive to being produced remotely from the customer and this led to a proliferation of outsourcing activities from the late 1980's (Heeks, 1996). Heeks (1998) reports that 75% of the work was done onsite and just under 25% of the work done offshore in the late 1980's. A report by the Software Technology Park, Kanpur[13] mentions that onsite work comprised 58% of export revenues during 1999-2000. In 2000-01, 51% of Infosys' revenues and 53% of Wipro's were from onsite work. In 2003-04, 41% of India's software export revenues came from onsite delivery models (NASSCOM).

A third approach is to completely shift work offshore, often to an Offshore Development Center (ODC) that is exclusively dedicated to one customer. This is becoming increasingly popular with the US and European firms who wish to take advantage of the lower costs of skilled labor in India, and have sufficient confidence in the company's ability to manage the project and deliver the software (Arora *et al*., 1999). Despite an average 12-hour time difference with India, a high-speed datacom link can provide a client in the US with a virtual 24-hour office environment, which almost cuts the development life cycle in half, thus ensuring speedy deliveries with high quality.[14] At the same time, the foreign client does not have to own the company in India, which is a completely different proposition with its own exposure to risks, change in asset base, managing headcount, accounting principles, and corporate governance. This is seen as a capital efficient way to rapidly ramp-up the company's product development effort.

An ODC typically involves a long term contract with an agreement on unitary pricing, and when projects are assigned by the client, negotiation is generally restricted to the resources that the project will consume—typical of the Time and Materials (T&M) nature of the software industry in India. Some companies such as HCL Technologies, with 29 ODCs, thus derive over 70% of their revenues from offshore work[15]. Some of the issues in choosing between onsite and offshore

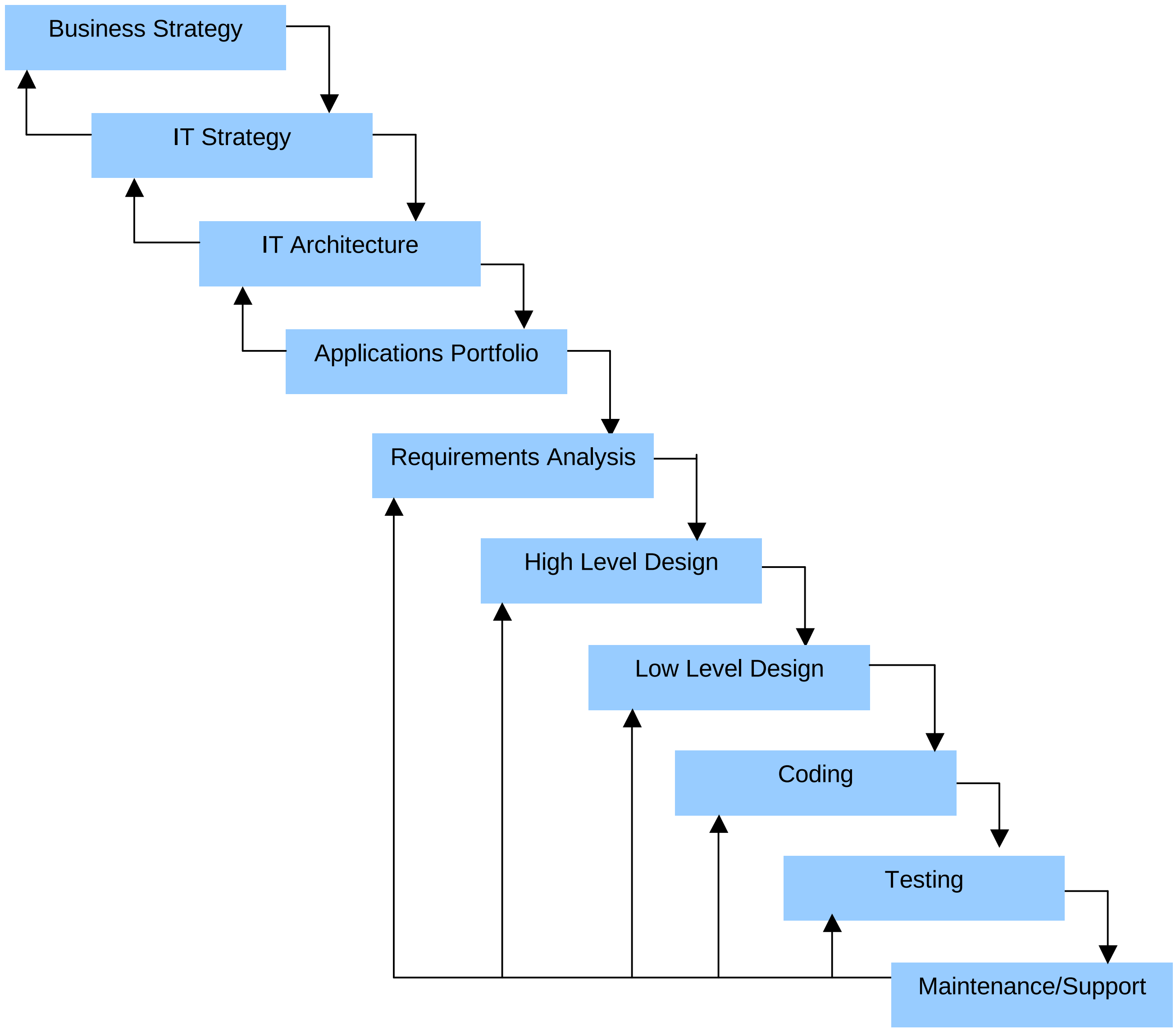
[13] http://www.STPIk.net.in/background.html
[14] Source: Businessweek, Jan 2000 issue
[15] India Today, http://www.india-today.com/btoday/20010521/feature3.html

strategies of development (Interviews) include trust, project size and importance to client's functioning, the need for interaction, the skill profile of the local company, and managerial perceptions: Indian engineers prefer joining companies that offer them a chance to go abroad and thus managers, in a bid to hire good employees and subsequently retain them, often opt for some amount of onsite work.

4.2.6. SPREAD ACROSS THE "VALUE PYRAMID"

In the past, clients usually hired Indian software personnel as programmers rather than system engineers or designers (Chakraborty and Dutta, 2002), although the situation has changed in recent years. Typically the initial stages of strategy, architecture design, requirement analysis, specification and system design are characterized by higher skill and greater value added, and the later stages of coding, testing and maintenance are characterized by lower skills and lesser value added. As the Indian software companies have gained in experience and capability, they have gradually moved up the software waterfall, shown in Figure 7.

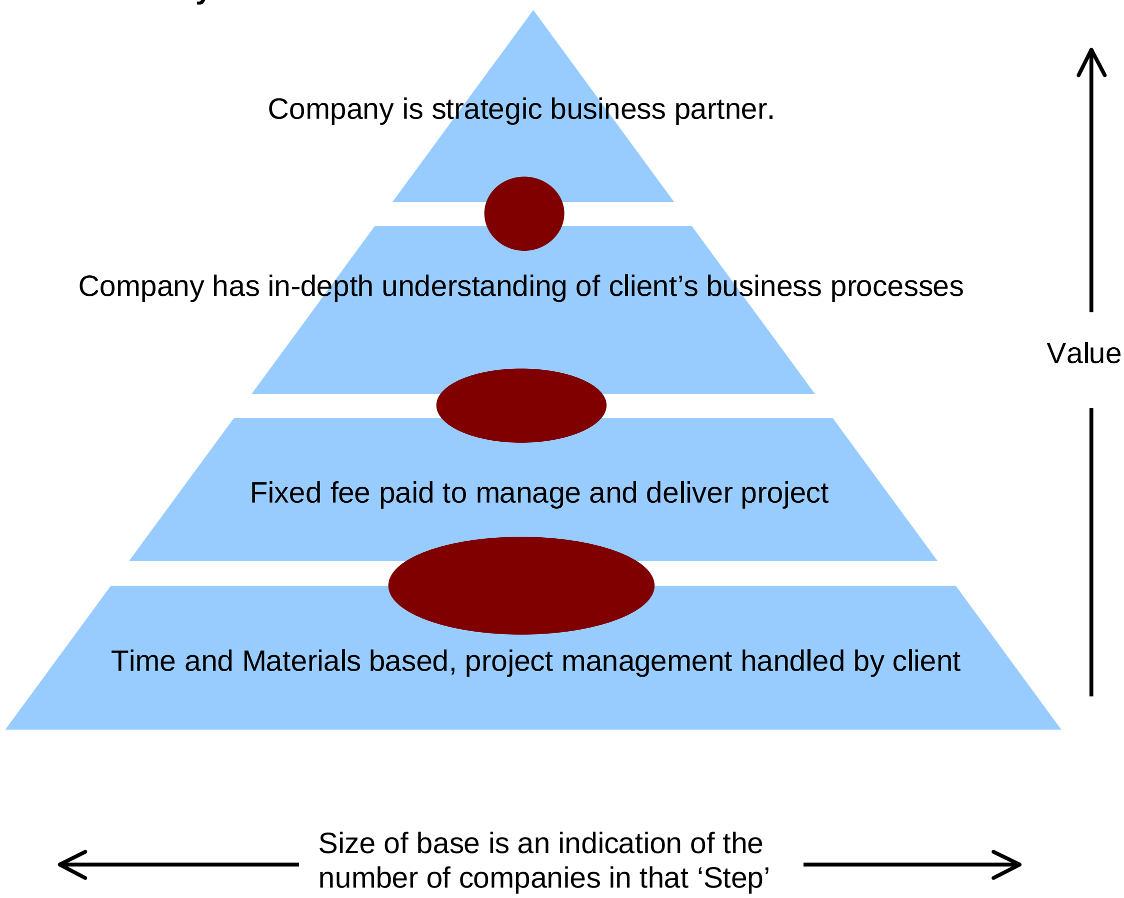
Figure 7: Software Waterfall: the stages in Software Development



Source: Adapted from Somerville (1992)

The Value Pyramid (Figure 8) is a contribution of this study; it illustrates the four different steps at which Indian software (service) companies position themselves. The pyramid is bottom-heavy, indicating that the number of Indian companies participating at a particular step increases as we move downwards. The trend in the industry is that existing companies move upward in this "Value Pyramid", while new companies continue to enter at different steps. At the first step of the value pyramid, the company's value proposition centers on the features and benefits that it offers its clients in terms of labor services. The customer is in a sense responsible for realizing the benefits, by requesting for the right skills or allotting the right modules. Project management is left to the client typically. Companies that position themselves here offer services in onsite and offshore development. The billing structure is typically T&M (time and materials) or cost-plus. Skilled labor and effective cost management is the keystone of this step.

Figure 8: Value Pyramid



As the company moves to the second step, it takes over project management and functions on a fixed cost, project-oriented billing structure. There is greater responsibility to deliver the project and to understand the best practices for the client, to effectively integrate the system into the client's profile. Requirement analysis and specification is the keystone of this step.

Moving to the third step requires a greater leap than moving to the second. It requires a deep understanding of the client's business processes, and technology must be cohesive with the business processes of the client. This step is characterized by a fine-tuned requirement analysis arising from the client's business requirements rather than project definition. The company is now responsible not just for an accurate understanding of the client's specifications and an exact and correct implementation of the technology, but also for the benefits accrued by the client via the technology nominated by the company. The third step allows a much higher proportion of value to be captured, because the benefits that customers realize can be quantified more easily, and because few competitors are able or willing to supply at the third rung (Interviews).

At the fourth and highest step, the company must align itself as a strategic partner with the client, and work to provide business solutions to the client rather than technological solutions. The company in a sense must share responsibility for its client's success. The keystone of the fourth step is the ability to cohesively integrate the client's strategy with the company's value proposition. Technology is no longer central to the value proposition, but is seen by the company (and not just by the client) as a tool in attaining its strategic vision (Interviews).

The inter-step ovals denote the fact that companies often straddle different steps of the value pyramid. It is difficult to climb up this pyramid, as it requires a repositioning of the company in terms of competencies, skills, business understanding, and reputation. Companies may exist within the same step with different revenues, and may even increase revenues and profits dramatically while staying at the same step. This is because the steps in the value pyramid are not related to revenues and profits in any way, but rather with business objectives and value propositions. Companies that function in the inter-step ovals use the lower step as a supporting platform (or cash-cow) for their activities in the higher step.

In the early years, Indian firms typically functioned in the lower steps of the value pyramid. This has changed in recent years, with companies spreading across the pyramid (Interviews). Work in the first step is characterized by a "Time and Materials" basis of billing, rather than a Fixed

Price basis, rather like a construction company. This follows logically from the way software export companies in India begin operations: through “professional service projects” or “staff augmentation services” or “body-shopping” for overseas clients. As trust builds, the client may allow larger fractions of the work to be carried out offshore, on a time and materials (or cost-plus) basis of billing. If the client is a major source of the company’s revenue, it may become an Offshore Development Center (ODC), handling projects exclusively for that client on a long-term arrangement. Negotiations for each project are then limited to the resources required in order to ascertain the time and materials required (Arora *et al*., 1999). One of the conventional paths for export service firms to upgrade is to become the “product developer” for their customer, albeit one that does not hold the intellectual property (Tschang, 2003) or benefit from the revenue potential of the product.

Between 1988-1998, at least 65% of export contracts were solely for programming work (Time and Materials billing) and the other 35% had a prominent fraction of programming work too (Heeks, 1998). In 1996, 85% of workers in Indian software exports were programmers (Heeks, 1996). There is a dire shortage of system analysts with 5-6 years experience. As programmers gain knowledge of system design by working on either domestic or export projects, they are attracted by job opportunities in foreign countries (typically the US) thus migrating (popularly labeled as ‘brain drain’). The reverse brain-drain phenomenon (discussed in Chapter 5) is more recent and refers to people, with both capital and years of experience in a product-environment, returning to India, resulting in a corresponding boost to the industry.

4.2.7. CHARACTERIZED BY CLUSTERS

Porter indicated that clusters of excellence characterize successful industries, and this is true of the software industry in India too. Some factors behind cluster formation are labor availability, quality of life, infrastructure, and proximity to previous employer and residence (Haug, 1991). Mumbai started as the main center for companies involved in software development though today most of its export volume is from TCS, which reports its group revenue through Mumbai. Firms are clustered in a few cities, notably: Bangalore (in Karnataka state), Hyderabad (in Andhra Pradesh state) and Chennai (in Tamil Nadu state). Table 9 shows clusters by export revenue and Table 10 shows clustering by number of software companies.

Table 9: Clustering by export revenue (US$ million)

Cluster	1999-2000	2000-2001	2003-2004
Bangalore	1057.5	1635.7	4022.5
Chennai	413.8	646.8	1693.5
Hyderabad	229.9	435.4	1116.7
Total exports of these 3 cities as a % of national software exports	43%	44%	55%

Source: Data from STPI; Newspaper articles.

Table 10: Clustering of Software Companies in India by number

Cluster	Number of STP companies, 1999	Number of STP companies, 2004
Bangalore	267	1322
Hyderabad	138	800
Chennai	67	866
Mumbai	28	250
Total	500	3238

Source: STPI

While only a fraction of Indian software companies are NASSCOM members, as the main forum for the industry the distribution of its member companies is shown in Table 11 and Table 12.

Table 11: Clustering of the 892 NASSCOM member-companies, 2004

City	% of member strength
Bangalore	23.5%
Mumbai	19%
Chennai	10.6%
Hyderabad	8.8%

Source: NASSCOM

Table 12: Clustering of NASSCOM member-companies, pre-2004

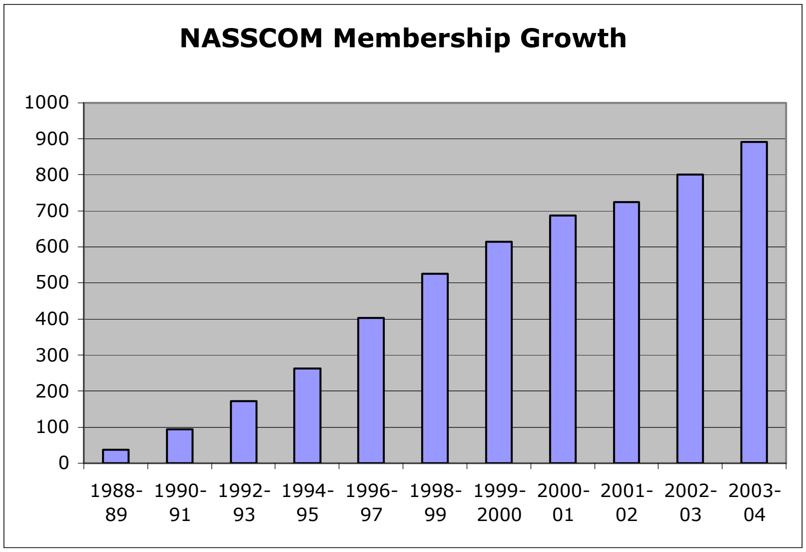
City	Number of NASSCOM-registered companies		
	2000	2002	2003
Bangalore	122	160	182
Chennai	55	72	92
Hyderabad	64	61	78
Mumbai	131	148	152
Delhi (incl. Noida & Gurgaon)	111	106	182
Kolkata	25	32	32
Pune	23	48	57
Other	69	73	79
Total	600	700	854

Source: NASSCOM

From this data, it can be seen that clusters characterize the software industry in India. This is in accordance with the general principle of Cluster Theory, which expresses that successful industries tend to appear in clusters.

In providing a background of the industry, an organization that merits mention is NASSCOM (National Association of Software and Service Companies), the premier trade-body and the chamber of commerce of the IT software and services industry in India. Started in 1998 with 38 members, today NASSCOM has over 900 members (see Figure 9) in the business of software development, software services, and IT-enabled/BPO services. A not-for-profit organization, NASSCOM has been the strongest proponent of global free trade in software in India, and its members account for over 95% of the revenues of the software industry in India (NASSCOM).

Figure 9: Growth in NASSCOM Membership: 1998 to 2004



Source: Data from NASSCOM (www.nasscom.org)

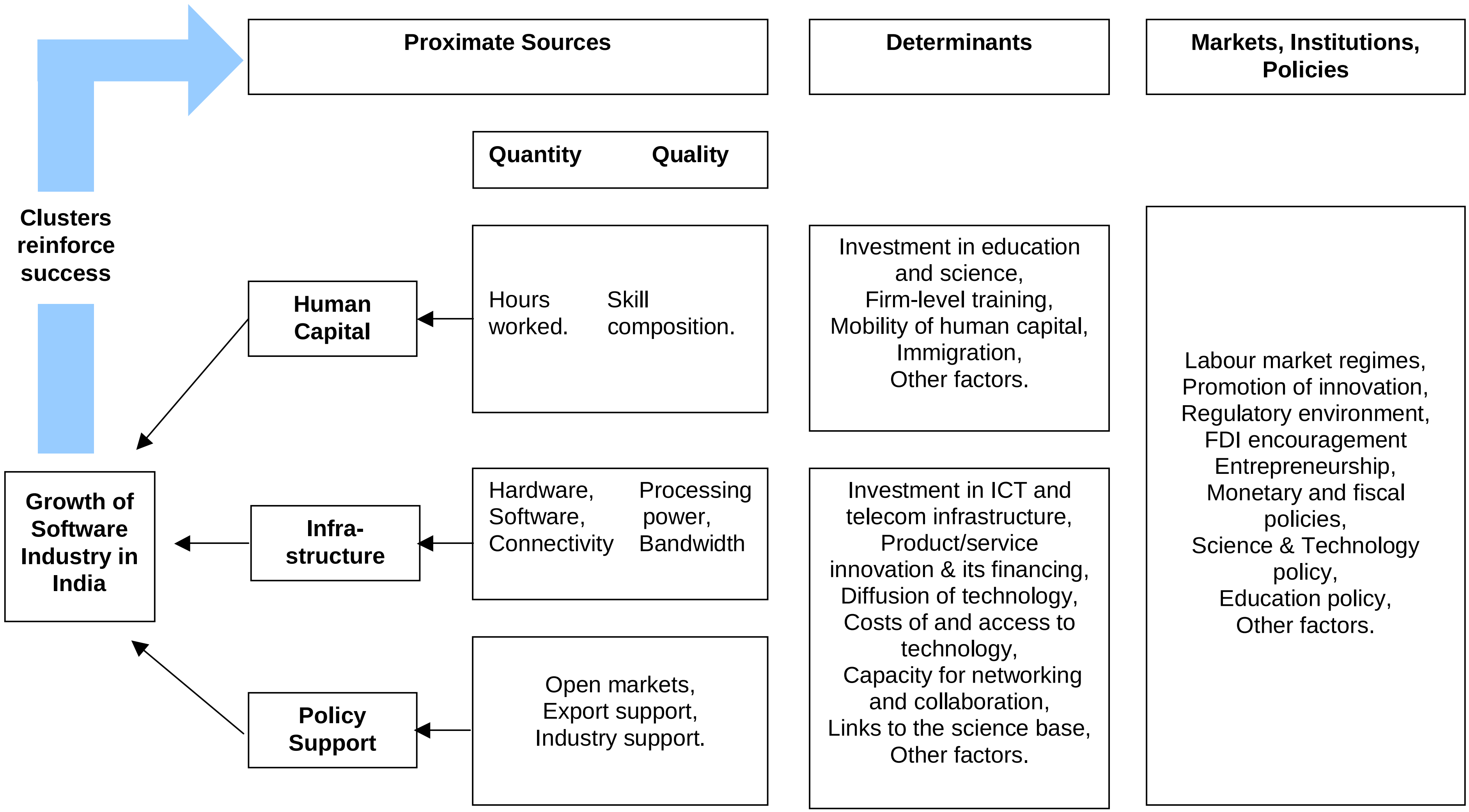
This chapter has described and analyzed the case that is being studied in this thesis. Both a country-level background and an industry-level background are provided. India as a country has not demonstrated a history of market efficiency. The software industry in India is service-centric and export focused and is known to provide high quality at a low cost. Companies in the industry participate in a people plus services export model, are largely focused on the lower steps of the value pyramid, and cluster together. The next chapter discusses the findings of this study, with focus on the role of government.

Chapter 5: Findings

Clusters tend to prove the adage that “nothing succeeds like success”. Once a cluster has reached a certain critical threshold, the natural dynamics tend to take over. At that point, the reasons for the success of the cluster are clear: all the factors required to succeed are available in abundance. The cluster’s success reinforces itself. The key point that is of interest then, is how the cluster reaches that critical threshold. This study finds that, for the Indian software industry, the Government of India was the primary driver behind cluster formation by providing infrastructure and outlining supportive fiscal and human resource policies. Figure 10 illustrates how Government policy resulted in the creation of three Critical Success Factors, and the rest of the chapter expands on these.

Figure 10 is an adaptation and enhancement of Figure 1. The original flow has been retained: that of markets, institutions and policies that drive the determinants, which in turn drive the proximate sources responsible for industry success. Examples of each driver are provided, within the context of the Indian software industry. In adapting the model in Figure 1 to the Indian context, the factors for the success of the industry become clearer, as well as their logical sequence. In the final addition to the left (block arrow feeding back into Proximate Sources), Figure 10 shows how the industry exhibits clusters of excellence, and how the clusters themselves further fuel the proximate sources of the industry’s growth.

Figure 10: Link between Government policy and growth of the software industry



Source: Enhanced OECD Framework (OECD, 2000)

5.1 Policy Support: Policies between 1956 and 2004

5.1.1 1956 TO 1974: CREATING THE INDUSTRY

While the early history of the use of software and software development in India predates this period, its usage was intimately linked with hardware and the growth of that industry (Heeks, 1996). The first computer was introduced in India in 1956 for use at the Indian Statistical Institute (ISI) a government organization[16] (Patibandla *et al.*, 2000). The ISI was based in Bangalore. The ISI rented out computational time to organizations that required it, because the computer was under-utilized. Large organizations in its vicinity, such as Dunlop, rented time for their payroll computations. For this, they required systems programmers. By introducing a computer through a public organization, the Government in effect created the seed of the first cluster, in Bangalore, giving rise to a natural demand for computational resources and for software programmers who could execute these tasks. This period saw the beginning of software development companies, notably Tata Consultancy Services (TCS) in 1968—TCS still is the largest exporter of software in India.

Until the mid-1960s, multinational hardware companies like IBM and ICL imported software and hardware. Through the 1960's, the Government pressured the wholly-owned multinational subsidiaries to dilute their equity, but the MNC market domination gave them the bargaining strength to resist (Heeks, 1996). The Government then started a public sector enterprise called the Electronics Corporation of India Ltd. (ECIL), in order to indigenize production (Heeks, 1996). This was an embodiment of "the thrust of the policy direction… on self-reliance through import substitution" (Heeks, 1996). ECIL designed and built a successful version of the PDP-8 of DEC,

[16] One interviewee related that the ISI 'rented' out computational time to organizations that required it, because the computer was under-utilized. Large organizations rented time for payroll computations. This gave rise to a natural demand for computational resources and for software programmers who could execute these tasks.

called TDC-12 (Trombay Digital Computer- 12) but concluded that while design and building of computers was possible in India, it was commercially unviable (Rajaraman, 2000).

Recognizing the demand for computational resources and the potential market for software export, while committed to a socialistic “control’ culture, the Government then came up with the “Software Export Scheme” in 1972. Under this scheme, a company could import as much computational resources as it liked, but in exchange it had to export a certain minimum amount of software (which varied from 100-150% of the cost of the hardware) over a period of four years, plus 1.5 times the cost of the wage bill annually. This gave rise to software development companies as an organic outcome! In 1974, TCS became the first firm to agree to export software in return for permission to import hardware, developing a stores and inventory control software solution for an electricity generation unit in Iran (Heeks, 1996). The same year, it developed a hospital information system in UK along with Burroughs Corporation, at that time the second-largest hardware company in the world[17]. Awareness of the industry’s potential grew with these projects, which were major landmarks in the industry (Patibandla *et al.*, 2000).

5.1.2 1975 TO 1984: ENCOURAGING LOCAL COMPANIES

The Government’s thrust towards self-reliance gathered momentum in this period. Through the late 1970’s, there was increasing pressure on multinational users and vendors to upgrade their technology, pay for all imports with equivalent exports and, above all, to dilute their equity or find an Indian company as a local collaborator for manufacturing their machines. While ICL agreed to dilute its equity down to 40%, IBM refused and threatened to ‘quit India’. Since they had a majority market share, their presence was necessary for the support and maintenance of most of the computer installations in India. This posed a dilemma to the Government. Witnessing the creation of a number of companies like TCS in 1968 and later Hindustan Computers Limited (HCL) in 1976 (Evans, 1997), the Government of India created the Computer Maintenance Corporation (CMC), in

[17] Dataquest India December 23, 2002

an effort to indigenize maintenance. CMC was given a monopoly of servicing all foreign-installed systems in India, 800 of which were IBM machines[18]. The Government then pressed its case with IBM who finally decided to leave India in 1978, rather than fall in line (Heeks, 1996).

This was a critical turning point for the industry: the departure of IBM underscored the Government's belief in the capability of the industry to stand on its own two feet; it created an Indian company that had from its start a large customer base and a team of capable individuals; and most importantly, it contributed to the growth of the home market (Patibandla *et al.*, 2000)—some of IBM's 1,200 former employees set up computer bureaux that later migrated towards software development (Heeks, 1996; Rajaraman, 2000; Interviews). Local hardware manufacturers drifted into software development or themselves turned into software development centers (Evans, 1995).

The Government didn't stop there: it made the smart move of further eroding vendor control, by instituting a policy that required the buyer (or CMC) to maintain imported machines (primarily mainframes). This meant that companies that wanted computational power had to effectively create an in-house maintenance team. This made buying a computer even more expensive. Companies began to set up departments that would sell services or computer time to other firms (Heeks, 1996). Since these computers were typically imported, another method to ease the import process was for the firm to undertake software exports. Smaller enterprises formed by groups of professionals who were once with IBM or with some of the earlier players such as PCS, also started during this period. Softek at Delhi (systems software) and Infosys at Pune and later in Bangalore (applications and embedded software) are notable examples. These clusters started close to the areas where these professionals lived. Despite the tough policy environment, by 1981-82, India was the only developing nation to have any significant software exports—$12 million—a substantial leap over the 1979 level of $4.4 million.

---

[18] Computer Maintenance Corporation (CMC) website: http://www.cmcltd.com/PROFILE/Profile.htm

5.1.3 1985 TO 1994: CREATING A POSITIVE IMAGE WITHIN AND OUTSIDE INDIA

The period between 1975 and 1984 was characterized by ‘Coalition Governments’, which never lasted long and led to discontinuity in political thought. The only perception that was pervasive through this period was that information technology would cause unemployment and was thus an evil to be tolerated as long as it did not reach beyond its rigid confines in the export enclaves. The Government had an impression of software as a necessary evil because some amount of high-end computing was required but at the same time it threatened to take over the low-end jobs as well thus increasing unemployment. The unstable coalition governments did not want to turn the vote bank against them and were particularly careful while implementing policies that were seen to be ‘supportive’ of the software industry. In order to progress, the Government had to find a way to convince the general population of the social benefits of computerization.

The Prime Minister during this decade was Mr. Rajiv Gandhi, who was IT-literate and was to be an important promoter of IT in India. In 1986, the Indian railways started computerization of their passenger reservation system. CMC carried out a highly successful implementation. Since the railways were so much a part of the ordinary citizen’s life, the railway computerization project played a major role in communicating the positive effects of technology, as well as in proving and further developing the capabilities of Indian software engineers to carry out projects on such a vast scale (Rajaraman, 2000). This was another turning point in the industry. The Government could now feel safe that promoting the industry would not turn voters against them[19]. They started seeing it as a valuable source of foreign exchange, and policy began to shift towards subtly encouraging it. In 1985, Texas Instruments (TI) set up its Indian operations, TI India (Private) Limited, a 100 percent export-oriented subsidiary (its first outside the United States), and began the work of CAD

[19] Though as the 2004 elections proved, this is thin ice. The IT-savvy ministers of Karnataka (Bangalore) and Andhra Pradesh (Hyderabad) were not voted back to their positions. Apparently, the voters do not believe that software will feed their children.

Design in Bangalore in 1986[20]. In that year, the Ministry of Information Technology (MIT) introduced a policy document on "Computer Software Export, Software Development and Training" (Saxenian, 2002). The STPI scheme was first mooted in 1990 as a tool to integrate India with the world markets by providing infrastructure for software companies that could not afford to build these themselves. The STPIs came into being in 1991[21], and proved to be critical in the growth of the industry—their role will be discussed in greater detail in the next section.

In December 1986, the Government of India announced their first policy for software export (Oberoi and Ragunathan, 1991), and the thrust of policy making has been inclined towards that segment ever since. While importing hardware and software became easier and restrictions on the domestic use of imported hardware were dropped, software export obligations (produced from imported hardware) were strengthened (Heeks, 1996). In 1989, duty on software import was raised from 60% to 107% (Heeks, 1995). This was an absolutely brilliant move. Rather than subsidising the industry, the Government made it *more* difficult to get access to critical computational power. The Government effectively *forced* private companies to develop software expertise or to give work to local software companies, reinforcing the basic factors behind the creation of a cluster. It is difficult to conceive of a strategy that could be as effective in kick-starting an industry.

In June 1990, there was a strategic alliance established between the software industry and the Department of Electronics (DoE). The National Association of Software Companies (NASSCOM) was created, as the voice of the industry. The strategic alliance between DoE and NASSCOM was critical for success because the DoE and Government could focus on what was needed and improve the felt needs of the industry (Interview). In a letter to us, N. Vittal (Secretary, DoE) reported that "at a meeting of the Committee held in August 1990, it was decided that if the software exports could go up from US$ 100 million in 1990 to US$ 400 million by February 1991, the demands of the industry will be considered by the Government. I gave the assurance to the Committee in that meeting. On 2nd September, 1990, in the NASSCOM meeting when I announced

[20] http://www.ti.com/corp/docs/company/history/1980s.shtml
[21] www.stpi.in

about this decision there was a gasp of disbelief! The target was considered to be too ambitious!" Although this target was only reached in 1994, the Government recognized the industry to have reached a stage at which benefits rather than taxes should be applied, and significantly revised policy, taking a more aggressive approach to promoting the industry.

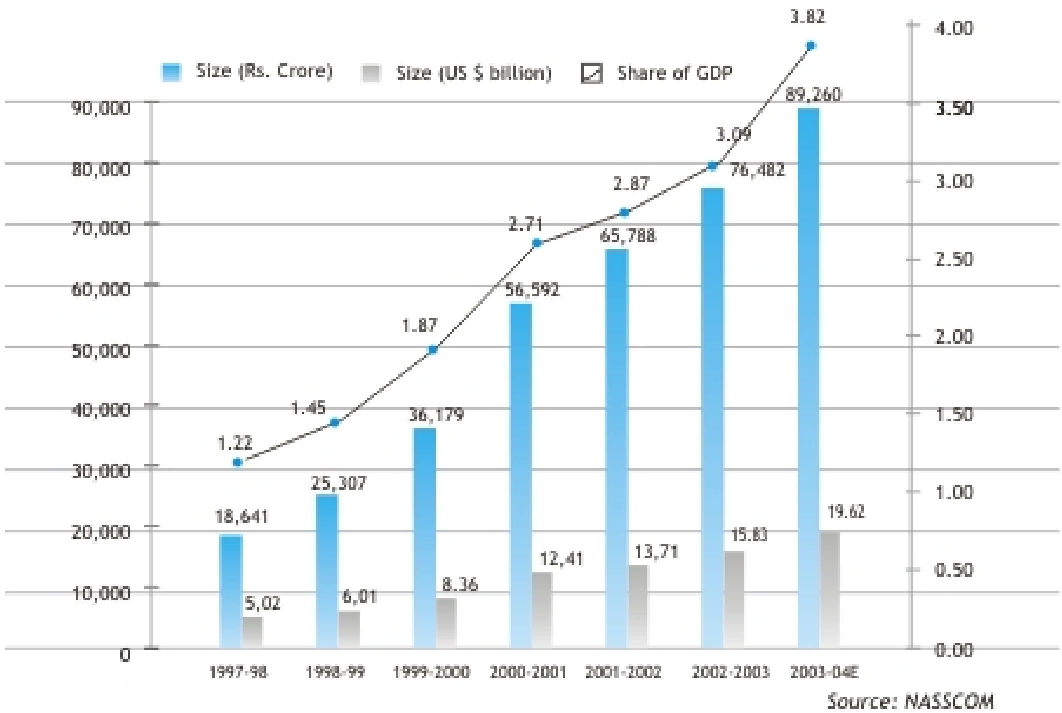
The year 1991 saw the start of substantial policy liberalization (Heeks, 1995). For example, duty for software import was reduced to 110% in 1992, 85% in 1993 and then split in 1994 to 20% for applications software and 65% for systems software. Indian companies could enter into agreements with overseas partners to import software, duplicate and sell them in India. The Copyright Act was amended and strengthened, the process for export incentive payments and creation of export-only units was streamlined (Heeks, 1995). The DoE began to take a more promotional role rather than its traditional regulatory role: creating subsidies for companies conducting R&D activity, a number of hi-tech programmes were started in collaboration with the United Nations Development Programme (UNDP): these and other similar initiatives created a large pool of R&D-oriented professionals. The significant devaluation of the Indian rupee provided the software industry with internationally competitive prices. Free import of telecommunication equipment into the export zones, reduction in charges for satellite links, and excise duty exemptions, served to reduce dependency on the domestic industry, which contributed to the competitiveness of the export sector. It also helped boost the domestic industry by raising competitiveness on the home front. The STPIs became a one-stop single-window clearance mechanism and export-oriented processes were streamlined in order to encourage companies to export software. Multinational companies viewed this liberalization positively and began to venture into India "once their old image of IBM-hating, socialist India had been dispelled" (Heeks, 1996). In fact, even IBM re-entered India, this time with an Indian partner! The Government had succeeded in changing the image of the industry within the country, as well as in the world at large.

5.1.4 1995 TO 2004: ACCELERATING INDUSTRY GROWTH

Post-1995 there was intense activity and excitement in India revolving around Information Technology, in parallel with the excitement around the world. The contribution of the software industry expanded from 0.5% of the GDP in the fiscal year 1991 to 1.5% of the GDP in the fiscal year 1995 (Iwami, 2000) to almost 2.7% in 2000-2001 and 3.82% in 2004 (NASSCOM), as Figure 11 and Figure 12 indicate. The data in Figure 12 and Table 2 are from different sources and differ slightly (e.g. US$12.2m vs. US$12.5m for the year 2003-04). This may be due to different rules for rounding, or differing exchange rates used.

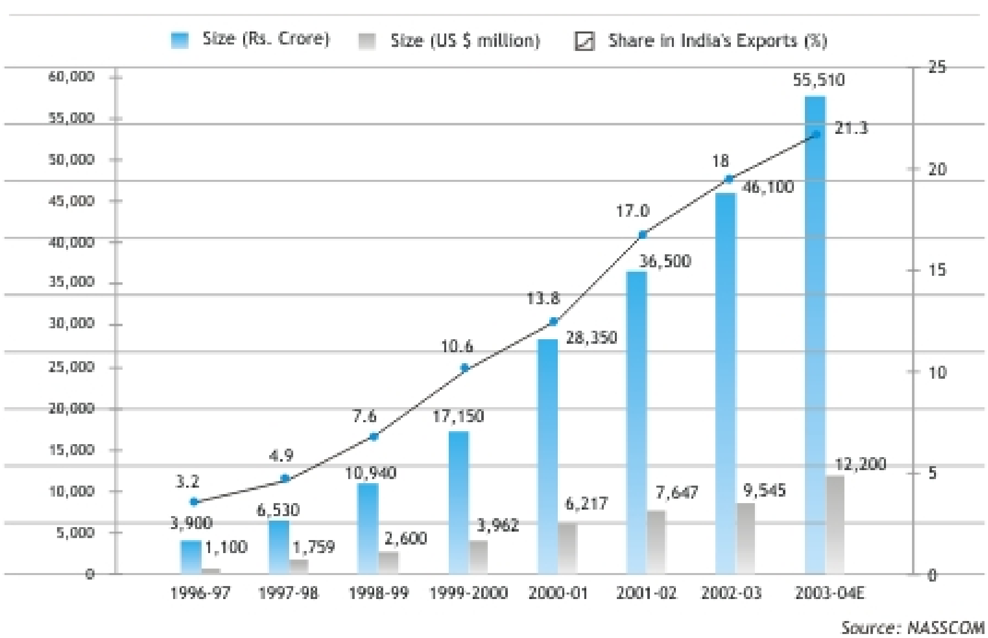
In 1998 the Government created a task force within the Prime Minister's administration for information technology/software development; and in 1999 the Government created the Ministry of Information Technology. The State Governments acquired corporate roles and embarked on ambitious projects to woo foreign investment within the state. Delegations (typically a mix of industry and government personae) were sent to other countries to entice foreign investment, and the Government instituted a policy that subsidized travel expenditure by 15% if to a country other than North America.

Figure 11: Indian Software Industry as a Percentage of India's GDP



Source: NASSCOM

Figure 12: Indian Software Exports as a Percentage of Total Indian Exports



Source: NASSCOM

The role of the Chief Minister has changed from political leader to CEO of the State. Indian cities have finally become the ‘national champions’ that Jessop (1998) talks about, competing with each other for investment and infrastructural facilities. While Karnataka was the first state in India to announce a special ICT policy in 1997 in order to overcome the city’s infrastructural constraints (Fromhold-Eisebith, 2001), other states such as Andhra Pradesh and Tamil Nadu have also since taken up an aggressive stance in attracting ICT investments, especially FDI (Foreign Direct Investment).

Constraints have been identified and steps taken to overcome them. The Government of India set up a National Task Force on Information Technology to examine the feasibility of strengthening the industry, and regular policies are being implemented[22]. Thus for example, venture capital has been the traditional source of finance for the software industry worldwide, yet there is a critical shortage of venture capital in India. In order to remedy this problem, the norms for the operations of venture capital funds have been liberalized. The Government of India is also actively providing fiscal incentives and liberalizing norms for FDI and raising capital abroad. An IT committee was set up by the Ministry of Information Technology, comprising Non Resident Indian (NRI) professionals from the United States to seek expertise and advice and also to step up U.S. investments in India's IT sector[23]. The Government enacted an Information Technology (IT) Act in 2000 to accelerate induction of IT in critical sectors of the Indian economy, and to provide a legal framework for e-commerce and prevention of computer crimes (Chakraborty and Dutta, 2002).

The software-driven IT industry has risen over the years, to the top of India's national agenda as an instrument and a model for the modernization of India's economy. Starting from the very first computer introduced in India in 1956, until today, the Government has consistently implemented appropriate policies at the appropriate time.

[22] National Taskforce on Information Technology, 1998.
[23] From www.indianembassy.org

5.2 Infrastructure Support: Software Technology Parks

One of the major contributions of the Government towards the growth of the software export industry was the development of the Software Technology Parks. The Software Technology Park of India (STPI, an autonomous society under the Ministry of Information Technology) scheme is a 100% export-oriented scheme for development and export of software, using dedicated data and communication channels, or occasionally in the form of physical export. The Software Technology Parks (STP) are, in effect, Government created clusters. STP complexes aim to provide (a) Physical space (b) Computing power and (c) Bandwidth.

With the STPI policy being implemented in 1990[24], there were seven such parks in India in 1991, with a total of just over 110 companies affiliated with them, as well as eleven such parks established by individual companies. The Department of Electronics (DoE) had set up a number of Software Technology Parks in select parts of India (18 as of 2004), to meet the following objectives:

1. To establish and manage physical and computing infrastructure for software exporters
2. Assist with the numerous approvals and certifications required for software exporters
3. Assist software development organizations with market analysis, and marketing support
4. To train software professionals

STPs were spectacularly successful because software was not a physical product and so the customs officials could not create too many problems (Kahaner, 1996). Furthermore, the DoE as a technical department was able to effectively provide “single window” services to the software exporters shielding them from the normal harassment of bureaucracy to which traditional exporters were subjected. 78 per cent of the country's total software exports is routed through STPI centres. As far as Bangalore is concerned, 95% of exports are routed through the SPTI centre here[25]. Table 13 below shows the share of exports routed through STPI centres. The “Total exports from India”

[24] STPI website: www.stpi.in
[25] http://www.deccanherald.com/deccanherald/jun16/isoft.htm last accessed November 15, 2005.

values in Table 13 differ slightly from the values in Table 2, possibly owing to different rules for rounding, or different exchange rates applied.

Table 13: Trends in IT export from units registered with STPs

Year	No. of units registered with STPs	Total exports from India ($ million)	Share of STP units in total exports
1991-92	164	164	na
1992-93	227	225	8
1993-94	269	330	12
1994-95	364	485	16
1995-96	521	734	29
1996-97	667	1085	46
1997-98	844	1750	54
1998-99	1196	2650	58
1999-00	5582	3900	68

Source: Joseph, 2002

5.2.1 INFRASTRUCTURE: INFORMATION AND PHYSICAL

A reliable and dependable communication system is essential for undertaking offshore development of software. STPI had established High Speed Data Connectivity (HSDC) facilities providing global connectivity at Bangalore, Hyderabad, Thiruvanthapuram, Gandhinagar, Bhubaneshwar, Noida, Mohali, Jaipur, Navi Mumbai, Pune, Chennai, Mysore, Manipal, Coimbatore, Vizag and Guwahati. These facilities include F3/E3/H4 IBS earth stations that serve as the International Gateways. The gateways are integrated with terrestrial wireless systems for local loop, or with terrestrial cable systems. The units operating inside the complex have access to these facilities through the Local Area Network, while those outside the complex, are extended these services to the cluster in the vicinity through a local loop.

At the time of origin, the DoE made a significant contribution by championing the provision of 64 kilobits per second connectivity. This was a great boost in the infrastructure for the exports.

Although under the rules of business, the Department of Telecommunications was responsible to provide the high-speed communication by way of earth stations, it did not agree to provide this facility as “it was not a priority” (Interview). The Government of India authorized the DoE to divert Rs. 120 million from an ongoing project for building the Semiconductor Complex at Mohali near Chandigarh, towards funding the earth stations. The STPs at Bangalore, Hyderbad, Gandhinagar, Thiruvanthapuram, Bhubaneshwar and Noida near Delhi came up with the earth stations in 1991-1992. Timesharing and time based charges for the use of earth stations was introduced as well. For example, instead of Rs. 4 million per annum paid by TI, the Software Companies could manage with Rs. 0.2 to 0.3 million depending on their volume of business. These proved to be critical success factors. In 2001, over 1400 dedicated, high-speed (64 kbps, 2Mbps and above) data-com links were being used by software exporting companies compared to 10 links in 1991 (NASSCOM).

Another important function of the STPI is to provide incubating infrastructure for start-up operations and Small and Medium Entrepreneurs (SMEs) to enable them to commercialize their operations without any gestation period. This enables the SMEs to avoid capital investment in the creation of captive facilities for themselves as well as facilitates the SMEs in setting up operations rapidly within a time-bound environment. State-of-the-art complexes have been built in co-operation with the State Governments, and a total area of 200,000 sq. ft. built-up space is now directly co-located with STPI offices nationwide.

5.2.2 BENEFITS OF STPI SCHEME

Several concessions were given to companies associated with the STPI, including:

1. Allowing 100% foreign equity participation. Capital invested, royalty, dividends, etc., can be freely repatriated after the payment of any income tax that may be applicable.
2. Not placing any restrictions on the geographical location of an STP complex.
3. Duty-free import of infrastructure equipment without incurring any export obligations. The STP complex is a customs bonded (import tariff free) area.
4. A five-year block of tax holiday during the first eight years of operation.
5. Exemption from domestic levies such as excise duty, and sales tax levied on capital goods acquired in India.
6. Permission to sell up to 25% of software exported, in the Indian market.

In summary, the STPIs were a key factor in building the momentum of the software industry, providing a central seed around which a local cluster could develop. STPs are amongst the most efficient government organizations (Kahaner, 1996), and a major value proposition was that they have enabled software exporters to have a single window clearance for all the approvals and clearances—a veritable quagmire to the uninitiated—of the various Departments of Commerce, Telecommunications, and the Reserve Bank of India. Evans (1992) quotes a DOE official saying `"[The STPI] broke 26 separate rules to accommodate TI's Bangalore subsidiary and are willing to break more"'. As a result of this initiative, software became an "easy" business to set up (Interview), and this perception contributed greatly to the growth of the industry.

5.3 Human Capital support: Policies and Institutions

Human capital has been considered one of the major reasons for the success of the Indian software industry (Arora *et al.* 2000; Interviews). The software industry is a human capital-intensive industry (Fernandes *et al.*, 2001). Investment in human capital, increasing returns to scale, and the impact of openness in international trade are all important in explaining the high rates of growth in developing countries such as India (Sengupta, 1993). This section discusses the Government's role in building a formidable base of engineers capable of contributing to the knowledge economy. Some of the measures undertaken by the Government are in the nature of policies. As such, they may be included in the "Policy Support" section of this chapter. I have however chosen to include those policies directly relevant to Human Capital support in this section.

5.3.1 SKILLED AND LOW-COST HUMAN CAPITAL

The wage comparisons (in 1995) of software personnel across 7 countries are shown in Table 14.

Table 14: Comparison of Salaries in 1995

Position	Switzerland	USA	Canada	UK	Ireland	Greece	India
Project Leader	$74,000	$54,000	$39,000	$39,000	$43,000	$24,000	$23,000
Business Analyst	$74,000	$38,000	$36,000	$37,000	$36,000	$28,000	$21,000
Systems Analyst	$74,000	$48,000	$32,000	$34,000	$36,000	$15,000	$14,000
Systems Designer	$67,000	$55,000	$36,000	$34,000	$31,000	$15,000	$11,000
Dev. Programmer	$56,000	$41,000	$29,000	$29,000	$21,000	$13,000	$8,000
Support Programmer	$56,000	$37,000	$26,000	$25,000	$21,000	$15,000	$8,000

Source: Data from http://www.sed.manchester.ac.uk/idpm/research/is/isi/isicost.htm last accessed December 2005

While salaries rise by around 5-12% year-on-year (higher rates for less developed countries), Table 14 highlights the difference in cost between personnel in India and in other countries. It appears from these statistics, as well as from other sources (Interviews; Heeks, 1996; Arora *et al.*, 2000; Fernandes *et al.*, 2001) that one of India's chief advantages was, and continues to be, its low cost skilled labor.

The skill of the labor is evidenced through certain anecdotal examples. One interviewee narrated how a team of software engineers in India was approached, among other teams across the world, to write a specific code to solve a problem. There was a time constraint of four days. The Indian team was able to complete it in eight hours. Another interviewee narrated an incident where an Indian company (Infosys) was able to deliver a project in a year and a half, when established players such as IBM and Accenture were unable to deliver it to the client's satisfaction even after two years. Fernandes *et al.* (2001) makes the general summarization of his interviews with US managers about the skills of Indian software workers as "Indian vendors were good and willing learners, receptive to new ideas, and flexible in terms of the software and hardware platforms for which they provide services".

5.3.2 INDIAN EDUCATIONAL SYSTEM CREATES SKILLED WORKFORCE

Murphy *et al.* (1991) looked at the growth implications of college enrollment levels in engineering. They discovered that there is a large direct and indirect positive effect of engineers on growth. While the Indian educational system is rated fifth-best in Asia overall[26], India boasts of some of the best technical institutions in the world, notably the Indian Institute of Science (IISc) and

[26] Times of India online article "India's education system fifth-best in Asia", dated 3rd September 2001. Rating based on "overall impression of quality… availability of high quality production labour, the cost and availability of qualified management staff, proficiency in English and overall skill of the labour force"

the six Indian Institutes of Technology (IITs). Other high-quality technical institutions are the Birla Institute of Technology, Pilani (BITS Pilani), Birla Institute of Technology, Ranchi (BIT Ranchi), Roorkee Technological University, and the Regional Engineering Colleges (RECs). The Government funds all these institutions, either entirely, or in large part.

According to Mueller (1994), appropriately targeted education is the key to improving the quality of labor in developing countries. Evidence suggests that development of human capital is highly correlated with growth rates in developing countries. The main strengths of the Science and Technology educational system in India is the fact that it offers programs at a low cost to students, is fairly well structured, and focuses on analytical skills. This was one of the key policies of the Nehruvian Government, post-Independence. The Government, under a Commission chaired by Dr Rajaraman, initiated the Master of Computing Applications (MCA) programme with the objective of training students with science and business degrees to develop applications software for managing enterprises (Rajaraman, 2000). The programme was initially offered at ten institutions and was seen to be a significant driver of the software industry in its formative years (Rajaraman, 2000). Table 15 shows the distribution of educational institutions in India, in 1996.

Table 15: Distribution of Engineering Colleges in India, in 1996

Region	**Number of Engineering colleges**	**Sanctioned capacity (number of students)**
Central	50	9470
East	25	4812
North (incl North-West)	140	25449
West	140	34165
South (incl south-West)	308	82597
Total	663	156493

Source: Ramarao (1998), as cited by Arora *et al.* (2000)

Initially, the industry's sole backward linkage with the universities was a demand for technically trained personnel. Today, the quality of education has been affected: while the syllabi have become more relevant to the needs of the industry, the enormous demand for software courses (due to the growth of the industry as well as the migration of experienced personnel) combined with a dearth of capable faculty has led to some dilution of quality[27]. Training institutions have sprung up around the software clusters, to equip candidates with the skills required by companies. These institutions develop linkages with industry in order to offer 'job placement' as one of their selling points. Intelligent English-speaking graduates are trained at these institutes; and armed with the requisite skills they join software companies since these are the companies that generally offer the most lucrative options.

5.3.3 GOVERNMENT CREATED A LARGE POOL OF ENGLISH-SPEAKING ENGINEERS

The number of engineers with postgraduate training in India had increased by almost 45% in two years, from 12,000 in 1987-89 to over 17,000 in 1990-92 (Fernandes, 2001). The growth in student enrollment in AICTE (All India Council of Technical Education) approved degree institutions in the 1990's has grown at an average rate of 11.5% per annum, with a growth of 29% from 1996-1997 and 19% from 1997-1998 (Fernandes, 2001). Table 16 shows the growth in the number of educational institutions between 1950 and 2002. From 1950-51 to 2001-02, the number of schools increased by 4.4 times, the number of colleges for general education increased by 23.6 times, the number of colleges for professional education increased by 11.6 times, and the number of universities increased by 10.1 times.

[27] World Bank, 2000

Table 16: Growth in Government-recognized educational institutions

Years	Schools (Primary, Secondary, High)	Colleges for General education	Colleges for Professional Education	Universities
1950-1951	230683	370	208	27
1955-1956	310703	466	218	31
1960-1961	397391	967	852	45
1965-1966	494476	1536	770	64
1970-1971	536050	2285	992	82
1975-1976	603895	3667	3276	101
1980-1981	664631	3421	3542	110
1985-1986	729555	4067	1533	126
1990-1991	792187	4862	886	184
1991-1992	805246	5058	950	196
1992-1993	814354	5334	989	207
1993-1994	822485	5639	1125	213
1994-1995	850528	6089	1230	219
1995-1996	866829	6569	1354	226
1996-1997	887180	6759	1770	228
1997-1998	912323	7199	2075	229
1998-1999	929341	7494	2113	237
1999-2000	956519	7782	2124	244
2000-2001	971054	7929	2223	254
2001-2002	1017159	8737	2409	272

Source: Data from Ministry of Human Resource Development, Government of India

Table 17 provides a region-wise listing of approved institutions offering an engineering programme, while Table 18 and Table 19 shows the distribution of engineering colleges and students in 2002 and 2004. The South (includes Bangalore, Hyderabad, and Chennai: see Figure 2, Map of India) has a large fraction of the country's engineering colleges. As of 2004, 52% of the total number of engineering colleges in India are in the South (including South-West) and 45.8% of the colleges in the country that offer a diploma in engineering; as well as significant fraction of all enrolled students: 53.8% of those enrolled in the country's engineering colleges and 39.1% of those enrolled in colleges offering a diploma in engineering. This is interesting given that software professionals are chiefly from South India[28]; this being reflected in the number of engineering institutions suggests the correlation between India's success in software and its human capital.

Table 17: Clustering of educational institutions in the South, in 1996

Region	% Distribution of engineering colleges	Sanctioned capacity (number of students)
Central	8%	9470
East	4%	4812
North (incl North-West)	21%	25449
West	21%	34165
South (incl south-West)	46%	82597

Source: Data from Ramarao (1998)

Table 18: Number and distribution of Engineering colleges in 2002 and 2004

Region	2002	2004
Central	64	112
East	71	114
North	87	106
North-West	99	153
South	269	496
South-West	108	207
West	140	158
Total	838	1346

Source: Data from AICTE

Table 19: Number and distribution of Engineering students in 2002 and 2004

Region	2002	2004
Central	17750	37195
East	16917	34016
North	20036	32298
North-West	22219	50645
South	71866	165757
South-West	37262	70788
West	41719	48990
Total	232229	439689

Source: Data from AICTE

[28] NASSCOM (2003) annual industry survey: 44% of software professionals in India are from the South. See http://www.indiainfoline.com/cyva/feat/itto.html, last accessed on 6th December 2005.

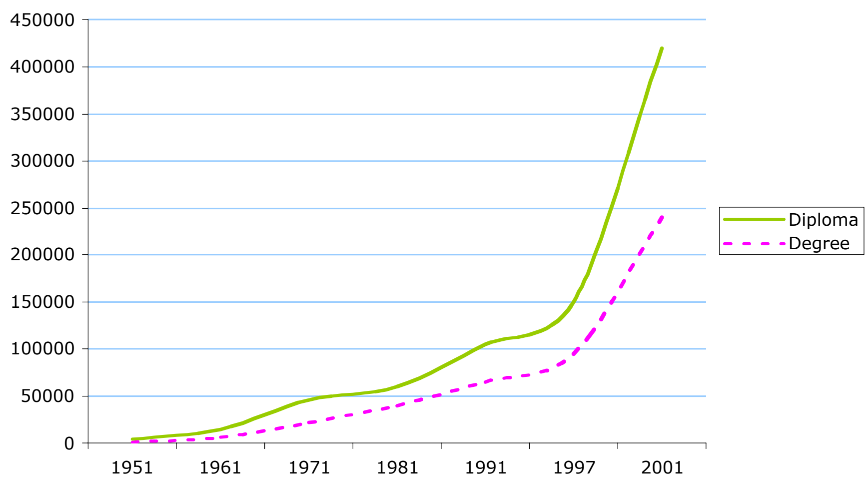
In 1997, the total stock of qualified scientific and technological manpower in India was 6.5 million, with 190,000 new degree holders at the graduate level and 41,800 at the post-graduate level added each year (World Bank, 2000). While companies prefer to hire engineering graduates (Arora and Asundi, 1999), there is an increasing trend of hiring diploma holders. This has resulted in a rise in the number of diploma engineering colleges and students. Table 20 shows the distribution of diploma engineering institutes and students in 2004. Figure 13 shows the growth in the number of engineering and technology graduates.

Table 20: Distribution of Diploma Engineering institutes and students, 2004

Region	**Diploma Engineering 2004**	
	No. of Institutes	**No. of Students**
Central	98	19830
East	97	14099
North	140	17003
North-West	150	25400
South	310	62311
South-West	251	11294
West	178	38365
Total	1224	188300

Source: Data from AICTE

Figure 13: Growth in Engineering and technology graduates



Source: Data from World Bank (2000); AICTE

5.3.4 PAST INVESTMENTS IN EDUCATING 'MIGRANTS' PAID OFF

Since the 1970's, many graduates of prestigious institutions such as the Indian Institute of Technology left India to pursue opportunities abroad, mainly the US. This "brain-drain" phenomenon placed these Government-funded educational institutions under much criticism. After all, the Government was spending huge sums of money on educating these students who then left the country. Despite protests from various lobbies, the Government persisted in supporting these institutions in providing inexpensive, high-quality education. Today, this investment is paying off.

There is now a trend of Indians who had moved to/settled in America, returning to India for personal or professional reasons. They bring back innovative ideas, venture capital, and access to markets. The bridge that these Indians have created has been a key factor in publicizing India's capabilities in the global market and in creating the opportunities for Indian companies to flourish. Leveraging on their exposure abroad, most of these 'foreign-returns' are starting their own firms. Take Rama Velpuri (story in Fortune magazine[29]) for instance. The Indian-born engineer is a U.S. citizen with a degree from Louisiana State, and he spent the 1990's working at Oracle. But when he started his own software firm, Oramasters, he decamped for Hyderabad, India. There he runs his company for only $30,000 a month (including payroll for his 25 employees) and pays $1,000 a month for a five-bedroom house in Hyderabad's upper-class Jubilee Hills (complete with three maids, a chauffeur, and a gardener). As engineers and other professionals return home—either temporarily or permanently—they transfer not only technology and capital, but also managerial and institutional know-how to formerly peripheral regions (Saxenian, 2002).

[29] From Fortune Nov 12, 2002 issue

5.3.5 CONTINUOUS EFFORT TO BUILD HUMAN CAPITAL

A shortage of complementary human capital prevents some countries from achieving higher growth rates (Lucas, 1990). Since software capacity is correlated directly with the size and skill of its workforce, there is no more important element of a country's efforts to increase software capacity than the development of its corps of software professionals (Tessler *et al.*, 2003). The industry has met the manpower requirements until now, and more institutions are being set up in order to meet the requirements in the future. The Government introduced the seven Indian Institutes of Information Technology to further promote the presence of quality IT education in India. As companies in India begin moving up the value pyramid, it may be expected that the number of individuals involved in basic research will increase, both within the private and public sectors.

The trend of business process outsourcing has spread its wings from software development and services to a wide range of business operations like call centers and payments processing. This is a human resource intensive industry, and even closer to the service model than the traditional software export business that has characterized the Indian software industry for the better part of half a century. The Government has been actively driving basic computer education in schools and colleges, subsidizing educational software. The key point to note about the BPO business in India is that it does not require software training, only knowledge of using a computer. This makes the pool of available resources vast. IDC (International Data Corporation) has predicted that the IT-enabled services market globally will account for revenues of US$ 1.2 trillion by 2006. With growth projected at 11 percent annually, the ITES/BPO segment will be one of the most significant business opportunities for the Indian software and services industry. Overall this sector grew at over 65 percent—upping revenues from US$ 1.6 billion in 2001-02 to touch US$ 2.6 billion in 2002-03 (NASSCOM).

While India's exploits in the software services arena is well known, a less known fact is that R&D services in India are now beginning to contribute a large amount to total exports.[30] The decades of investment in a science-oriented education are thus beginning to pay off. A 2001 Merrill Lynch report puts the figure at US$ 0.8 – 1.0 billion for the year 2000-2001 (NASSCOM). Wipro's R&D revenues have increased from US$ 15.97 million in 1995 to US$ 194.95 million in 2000, and the division accounted for 52% of Wipro's revenues in the fourth quarter ended March 31st 2001[31]. TCS earns about US$ 103.2 million from its R&D services. HCL had 200 people in R&D services in 1996. As of 2000, they had 2,200 and the division earns US$ 206.42 million for the company, 76% of its total revenues in 2000-2001[32]. Increasingly, companies are looking to move into R&D as a substitute for product development, as R&D does not require the capital or marketing 'guts' that Indian companies are said to lack (Interviews). Intellectual property development is now a major objective of the larger firms. Wipro derives over 26% of its revenue from selling intellectual property via its services: it develops 'technology building blocks' that are integrated into the solutions it provides to its clients; but it retains ownership of the blocks themselves[33]. The 2001 Merrill Lynch study found only one U.S. or European patent from the Indian software industry, and it was issued to Wipro (NASSCOM). Yet work at the Texas Instruments facility in Bangalore has generated 25 U.S. patents for the US parent!

In summary, the Government of India has provided favorable policies, infrastructure, and a pool of human capital; each of which has proven vital to seeding and cultivating clusters of excellence within the Indian software industry. The next section further illustrates this by discussing how Government did not play an active role in developing the Silicon Valley cluster, while Government did play an active role in developing the Bangalore cluster.

---

[30] Businessworld, 27 August 2001
[31] http://www.wipro.com/newsroom/newsitem2001/newstory73.htm
[32] 2001 Merrill Lynch report
[33] Businessworld, 27 August, 2001

5.4 Discussing Clusters I: Silicon Valley[34]

Silicon Valley is home to one-third of the 100 largest technology companies created in the United States since 1965. The market value of these firms increased by US$ 25 billion between 1986 and 1990, and in 1990, exports from the valley formed one-third of the US$ 33 billion total for electronic product export of the United States (Saxenian, 1994). Clearly, these revenues are drastically different from those of the Indian software industry. The focus of the Valley cluster on software products rather than software services is the main reason for this difference. In fact, there are many companies in Bangalore that provide software services to the companies in the Silicon Valley. As such, companies in the Valley are higher up in the value chain compared to companies in Bangalore.

The Silicon Valley origins are usually traced to the start of Hewlett-Packard Company (HP), in a small garage in Palo Alto. Two Stanford students—William Hewlett and David Packard—were the founders, inspired by their mentor, believer, and early investor Frederick Terman (sometimes referred to as the Father of Silicon Valley). Terman was a professor at Stanford and a primary catalyst for the university-industry collaboration that the Valley is famous for. Through channeling research grants into local firms, opening graduate programmes to working people in the local industry, and arranging field trips for students to the region's electronic firms, he managed to build a tightly-knit relationship between the university and the local industry. One of the key developments promoted by Terman was the opening of the Stanford Industrial Park, offering tenancy to companies associated with the University. This cluster grew rapidly due largely to postwar military spending, and by 1961, the park had 25 companies and 11,000 people in it. These companies had strong linkages with Stanford, and were focused on technology innovations.

Just as Hewlett and Packard played an instrumental role in shaping the philosophy and attitude of the Valley (the "HP Way"), a company called Fairchild Semiconductors played a vital

[34] This section is a summary of Interviews, books, papers and articles on the topic (see for example Saxenian (1994), Kaplan (1999), Kenney (2000), and Rosenberg (2002).)

role in being the unsuccessful parent of several very successful spin-off companies, including Intel. Of the 30-over semiconductor firms in the Valley in the 1960s, the majority of them were offspring of Fairchild. The experience of working at Fairchild Semiconductor Corporation served as a powerful bond for many of the region's early semiconductor engineers, who refer to their early training in the "Fairchild University". However, the habits of close co-operation in the Valley predate the semiconductor industry, to the origins of HP—where Hewlett and Packard became very involved in the formation and growth of other companies, going out of their way to share what they had learned with budding entrepreneurs. Certainly, innovation and information was "in the air". Mobility was the norm rather than an exception, and turnover was high. Employees would get their experience at established companies, and then set out on their own, starting small ventures that provided them with a sense of independence and accomplishment.

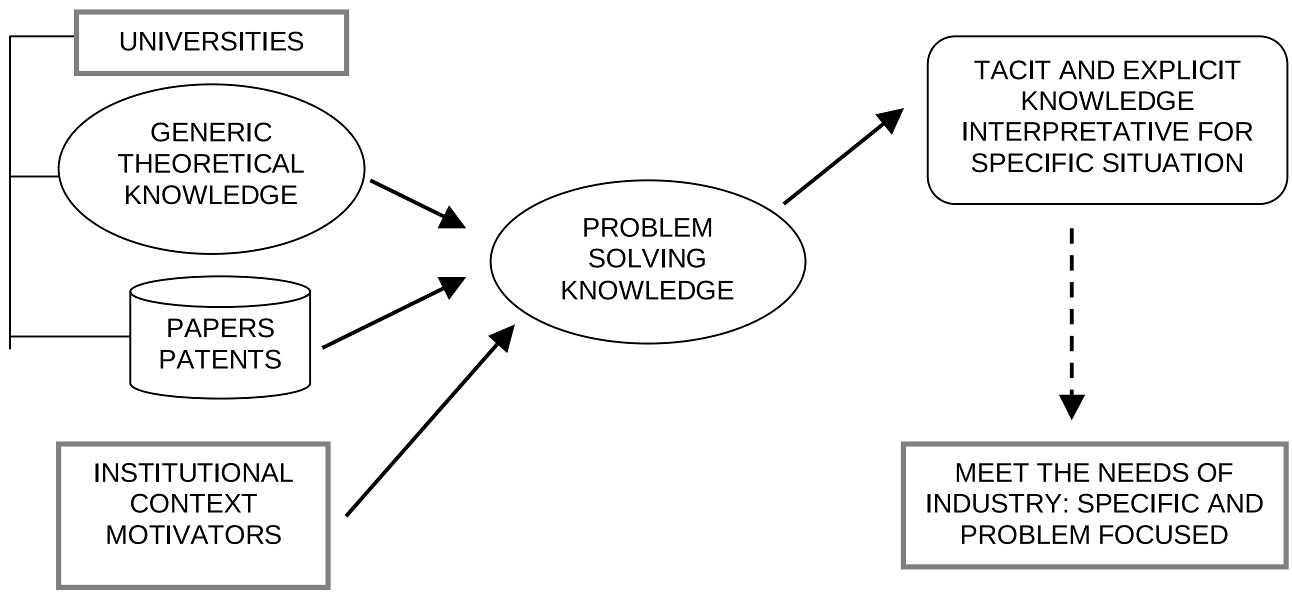
Stanford University played a key role in the evolution of the Valley. Through the mentoring of its staff (such as Terman), the high caliber of its students, its policy of close interaction with industry, its funding of start-ups, and its channeling of research funds to local industries, Stanford gave the technological stimulus that the cluster needed in the early phases of its growth. It also shaped the overall direction of the cluster, making it known for innovation in technology. In the 1960s-1970s, the University of California at Berkeley too became an important technological resource for the industry. By the mid-1970's, it was granting as many doctoral degrees as Stanford, and it had become an important centre of research in semiconductors and computer science. The state colleges may have been overlooked, but these were vital as well for the supply of skilled manpower to the industry, particularly because they were very sensitive to the needs of the local industry through jointly structured programmes and classes conducted on company premises.

Although the Valley took a beating during the collapse of the semiconductor business, by the 1980s it had surpassed Route 128 on the other side of the coast, as the national centre of computer systems innovation. By this time, repeat entrepreneurs were common, though the Valley had lost the tight-knitted sense of community that is associated with a small group of people. The largest wave of start-ups started in the late 1970's and accelerated during the 1980's. Firms diversified into many different aspects of technology including flash memory, handheld computer, multimedia, virtual reality, ICs and workstations. The spirit of innovation thrived, not just in terms of technologies, products, and business models, but also in the corporate structure and the culture that the firms embraced. Companies in the Valley preferred local suppliers particularly for technologically complex or customized parts. The desire for geographic proximity was not reducible by cost considerations due to the difficulty of creating good relationships over distance. This led to a thriving cluster as industries both upstream and downstream set up operations in the Valley to benefit from the close interactions they could have with their suppliers and customers. Proximity enabled firms to come out ahead in the global market due to more efficient networks with their local suppliers, and the sense of paranoia that local competitors inspire.

As the entrepreneurs earned returns, the financing ability of the Valley grew, and venture capital replaced military budgets as the chief source of funding. A combination of university research, military spending, and entrepreneurial risk-taking thus fueled the growth of the Valley. As employees moved from one company to another, they took with them technical expertise that drove innovation in product research, design and development so that Silicon Valley could benefit from the best innovation produced in the entire cluster rather than the best innovation produced by each company's proprietary research and development efforts (Saxenian 2000).

From this account, it is clear that the university-industry nexus was the primary driver that seeded the Silicon Valley cluster, illustrated in Figure 14. As we shall see, this is very different from the factors behind the emergence of the cluster in Bangalore. As the skill and knowledge of the cluster grew, it became easier to convince industries to relocate there, particularly given the area's pleasant climate and warm culture. And after a while, the natural dynamics of the cluster took over.

Figure 14: Linkage between Universities and Industry



Source: Adapted from Chakrabarti (2001)

Stanford, Berkeley and the State universities played a significant role in cluster formation, through the creation of “generic theoretical knowledge”, papers, and patents. These, along with other context motivators such as a growing military budget, contributed to “problem solving knowledge” that was useful for specific commercial applications. Firms started by people associated with the universities benefited from the physical proximity, and thus the cluster grew.

5.5 Discussing Clusters II: Bangalore[35]

The city of Bangalore, with a population of 6.52 million concentrated in an area of 2190 sq km, is one of the fastest growing cities in India. One main reason for this has been the explosive growth of the software industry, which has given Bangalore the title of “Silicon Valley of India”. More than half of the 778 foreign stand-alone R&D centers established by international corporations in India between 1999-2003 were in Bangalore[36].

Bangalore was a charming small town with a number of high-tech industries, a low cost and skilled workforce, and a mild climate. The city is situated 3000 feet above sea level, and is well known for its comfortable climate, its ample greenery, and lately, its high density of pubs! A recent Newsweek article included Bangalore in the list of the world’s funkiest cities, with London, Paris, New York, and Beijing. The city offers excellent schooling—both primary and tertiary (see Figure 15), entertainment facilities including clubs, racetracks and golf courses, and is a rich cultural centre as well. Bangalore was known as the “Pensioner’s Paradise” (which attracted senior people to set up their companies or subsidaries there). Regarding industry, Bangalore has a long history as a centre for textile production in the late 19th and early 20th centuries. During the Second World War, several public sector companies (including Hindustan Aeronautics, Bharath Electronics, Hindustan Machine Tools, Bharath Earthmovers) were set up under the influence of the Government of Mysore, thus creating the other main part of the economy of Bangalore—public sector enterprise. Bangalore was chosen for these because of its educational and scientific resources, and its strategic location away from the borders of India.

During the 1950s and 1960s, Government of India initiatives in locating public sector research and production facilities in Bangalore were dominant. Their direct impact, including management of their own townships, housing schemes, and transport systems, was supplemented by the numerous subcontracting opportunities they provided for small and medium enterprises.

[35] This section is a summary of Interviews, books, papers and articles on the topic (see for example Heitzman, 1999; Holstrum, 1998; Saxenian, 2002; Ramarao, 1998).
[36] India Business Insight, November 2003

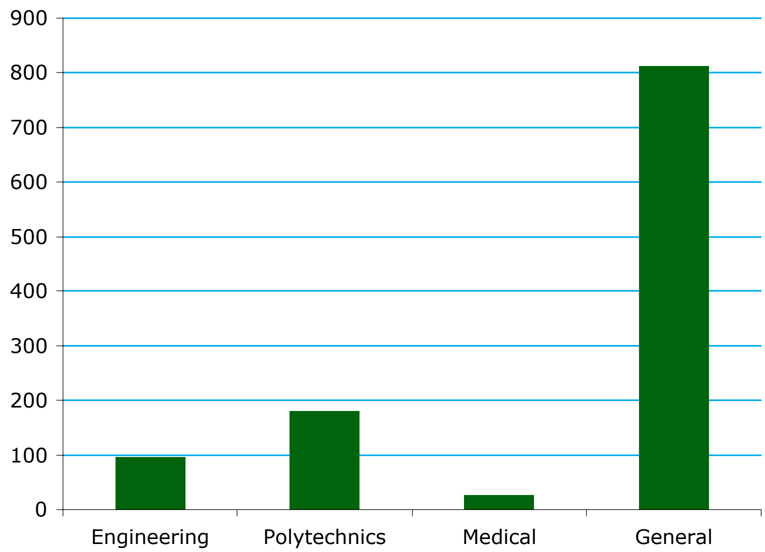
This was the beginning of an industry cluster. From the late 1960s through the 1970s, there was a rapid growth of state government bureaucracy, employment and eventually state-run businesses. During the 1980s, Bangalore began to experience the effects of preliminary 'liberalization' and private enterprises became growth engines, especially in microelectronics-based companies.

The Indian Telephone Industries (ITI) was established in Bangalore in 1950 in order to provide equipment to the Department of Telecommunications (DoT). ITI had a significant impact on Bangalore because of the large workforce employed there and the many opportunities it offered to subcontracting firms to grow in the Bangalore area. By the 1970s, political interference in this public sector company combined with retrograde technological decisions to cripple ITI's long-term competitive posture. The management of ITI took steps to upgrade its technological profile and modernize its management techniques. Although ITI was under pressure to develop locally or to indigenize modern equipment, it had regularly engaged in arrangements for technology transfer with multinational corporations. By the mid-1990s ITI had technical collaborations with 16 foreign firms—including ALCATEL, DSC Communications (Denmark), AT&T, and NEC Japan. The skill upgrading through technology transfer and the tendency of ITI to sub-contract to companies based in the vicinity together created a thriving micro-electronic cluster.

Under the economic paradigm dominant until the 1980s, the structure of high technology innovation rested with a number of government-supported research establishments (the apex in Bangalore being the Indian Institute of Science) and with a limited number of large companies, such as ITI. In addition to their large internal labor forces, these companies relied on subcontracting of specialized components from a number of engineering and production firms, which were effectively captive to the market provided by the public sector. Thus Bangalore enjoyed a thriving cluster of small and medium enterprises connected by contractual arrangements to the public sector.

The concept of Bangalore as a 'Silicon Valley' took off in the mid-1980s under the impact of Rajiv Gandhi's policy of economic liberalization in several high technology fields, including electronics. Texas Instruments chose to set up a unit in Bangalore because of the ability of technical personnel to communicate in English and to absorb training, a potential labor pool emerging from the Indian Institute of Science and other educational institutions, the already installed base of electronics industries and subcontractors (through the presence of ITI), the attractive climate, and relatively cheap real estate.

Figure 15: Number of colleges in the Bangalore cluster in 1997

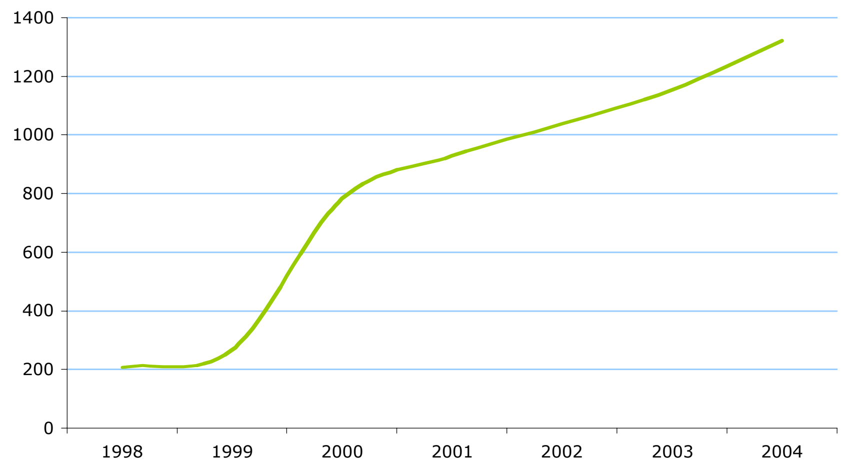


Source: Data from Ramarao (1998), as cited by Arora *et al.* (2000)

In a successful case of technology transfer, Texas Instruments set up a 64 Kbps data link and later turned it over to the Department of Telecommunications (DoT). This allowed the Bangalore team to develop and support software and transmit code online to the US and other locations globally. Texas Instruments India began in 1986 with 26 engineers, a total staff of 33, and revenues of US$ 0.5 million. By 1994 it employed 230 engineers, a total staff of 270, and generated revenues of US$ 6 million. Another example of a 'pivotal' company is Infosys. Infosys Consultants began in 1981 with an investment of US$ 300 (lent by the wives of the founders) and with N R Narayana Murthy as Chairman and Managing Director. The original purpose of the company was to make use of inexpensive but well-trained software engineers in India to provide offshore and onsite consultancy on corporate programming projects mostly in the US. The company was, in essence, a body-shopping centre that exported labour and expertise, and thus was a precursor of the many software houses, both Indian and foreign, that later grew in Bangalore. Infosys competed as a vendor offering turnkey contracts for software engineering projects; used the difference in time zones between India and the US to allow 24-hour productivity in maintenance operations as customer and vendor teams were able to work in relays; and pushed the concept of the ‘offshore software development centre’ that functioned as an extension of a customer’s software staff. In 1993 the name of the company was changed to Infosys Technologies and there was an initial public offer of stock. By 1997, Infosys was getting 87.12 per cent of its earnings from exports and 76 per cent of its business from the Americas, and thus stands as one of India’s great success stories in offshore software consultancy and innovation.

Today, there are technology parks that are highly modern locations for multinational companies, such as the International Technology Park Limited (ITPL) and Electronics City. The Bangalore ITPL was built as a self contained facility with its own captive power supply and satellite links. Built to international standards it supports high-tech and non-polluting industries such as software development, electronics, communications, research and development (R&D) and financial services. The ITPL represented a successful model of a joint venture in IT between India and its foreign partners. The ITPL was a joint venture between the Government of Karnataka, the Tata Corporation and a consortium of Singapore companies. Initiated in 1997, the first stage of ITPL was completed in 1999 at a cost of US$ 480 million and officially launched in January 2000, and stage 2 was launched in November 2000. Encouraging demand for IT facilities has enabled ITPL to initiate stage 3 of its expansion, to support the ever-increasing number of software companies in Bangalore (almost 1400 by the end of 2004, see Figure 16). The ITPL remains the benchmark for IT parks in India with its world-class infrastructure, and it has the highest number of occupants compared to other Indian IT parks. The success of these IT parks also depended on the speed of satellite communications. Companies with microwave antennae could be connected by satellite uplinks to clients anywhere in the world. Video conferencing is also a norm for Indian IT teams to confer and discuss problem solving with their overseas counterparts dispensing the need for physical presence. The Electronic City in Bangalore also houses a number of established IT multinational companies (MNCs) such as Texas Instruments, Hewlett Packard and IBM. Billion dollar Indian companies such as Infosys and Wipro are also located at Electronic City.

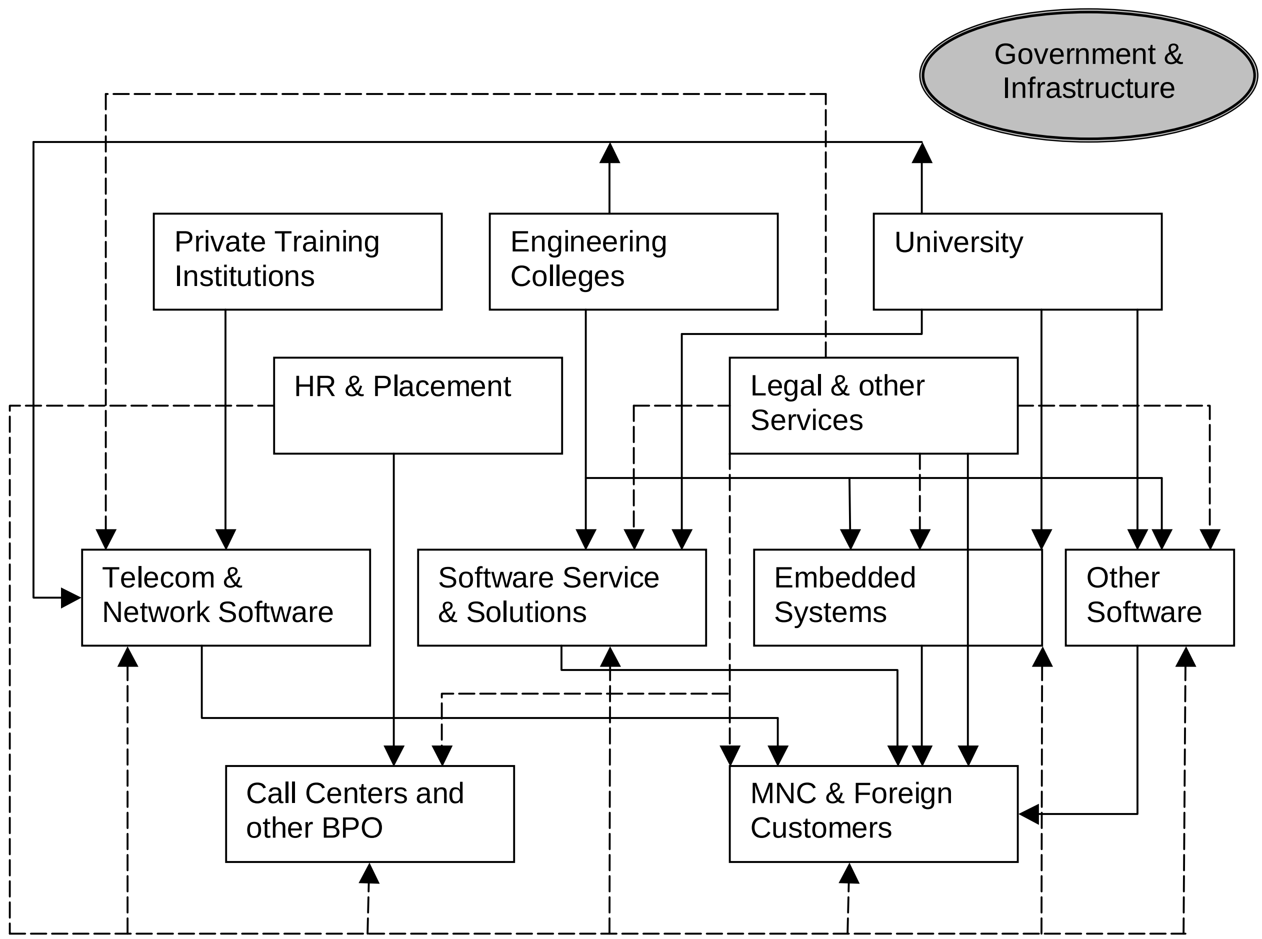
Figure 16: Growth in number of software companies in Bangalore



Source: Data from NASSCOM and STPI

Figure 17 is a contribution of this study, showing the different participants in the Bangalore cluster. While the transition to a new paradigm was being completed in the 1990s, it was clearly underway by the early 1980s. Entrepreneurs emerged from government-supported institutions and utilized their contacts there to understand markets, opportunities, and create new businesses. The bold lines direct (integral to the business) links in the eco-system, while the dashed lines indicate indirect (supporting business) linkages. For instance, Telecom and network software companies require legal services although these are not integral to their business. They also require skilled human resources from the private training institutions, engineering colleges, and the universities, and these resources are integral to their business. BPO-related work and software service related work are the two final outcomes, represented by the boxes "Call Centers and other BPO" and "MNC & Foreign Customers". Government and Infrastructure are shown in a grey oval, separated from the main figure, to indicate their overarching influence on each participant in the eco-system.

Figure 17: The software industry cluster in Bangalore



From this account, the Government's role in bringing the Bangalore cluster to its critical threshold before the natural dynamics of the cluster took over is clear. Unlike Silicon Valley, the Government in India played a crucial role in developing the Bangalore cluster, by building human capital through educational institutions and public sector enterprises, in addition to nationwide investments in infrastructure and supportive policy-making.

Chapter 6: Discussion and Conclusion

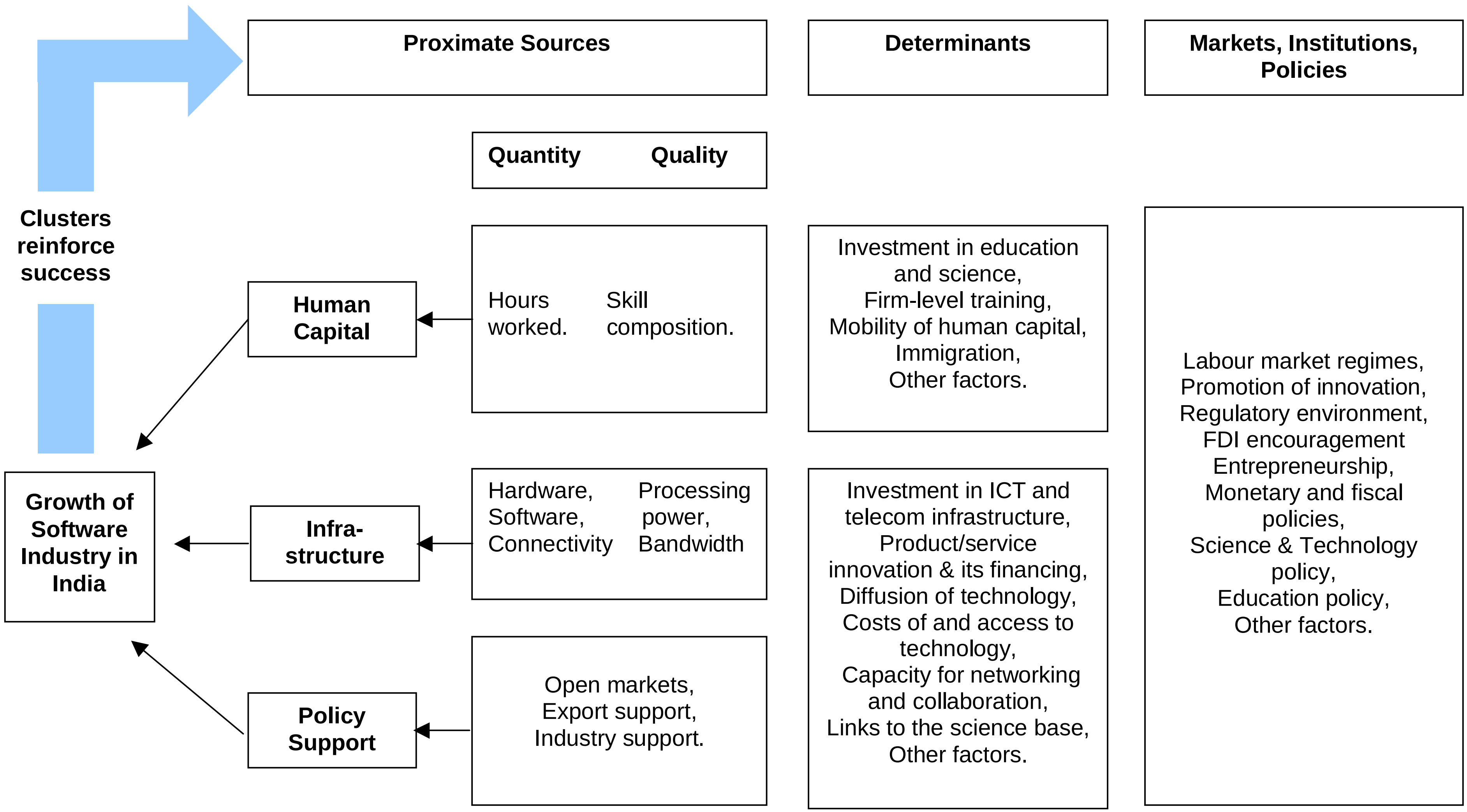
The last decade has witnessed remarkable changes in the Indian software industry. Several Indian software companies are listed on NASDAQ, over 250 Fortune 500 companies have outsourced some component of their business process to India, an increasing number of multinationals are investing in India (Table 21) and the number of software companies in India is steadily increasing. This thesis studied the role of the Government of India in this growth. The OECD (2000) model (Figure 1) was adapted and enhanced, as shown in Figure 18, to form a framework within which the role of Government could be examined.

Table 21: Key software players investing in India

Company	Activity in India
Hewlett Packard	Finance shared service centre in Bangalore; intend to make Bangalore their global center.
ComputerVision	80% of global R&D now done in Pune.
Novell	R&D center in Bangalore
Oracle	OS for Oracle's Network Computer written in Bangalore office.
Baan	80% of global R&D now done in Hyderabad.
Microsoft	First R&D center outside of the U.S. is in Hyderbad.
Boeing	R&D centers in India.
British Aerospace	R&D center in Bangalore.
Adobe	R&D center in New Delhi.
Lucent Technologies	R&D centers in Pune and Bangalore.
British Telecom	R&D center in Pune.
AOL	R&D center in India
SUN Microsystems	Invested $50 million in R&D center in Bangalore.
AT&T	Invested $50 million in R&D center in Bangalore.
CSFB (iNautix)	Invested $12 million in an ODC in India.

Source: Internet search (September 2005)

Figure 18: The adapted OECD model, showing Government influence in cluster creation (redrawn from Figure 10, p45)



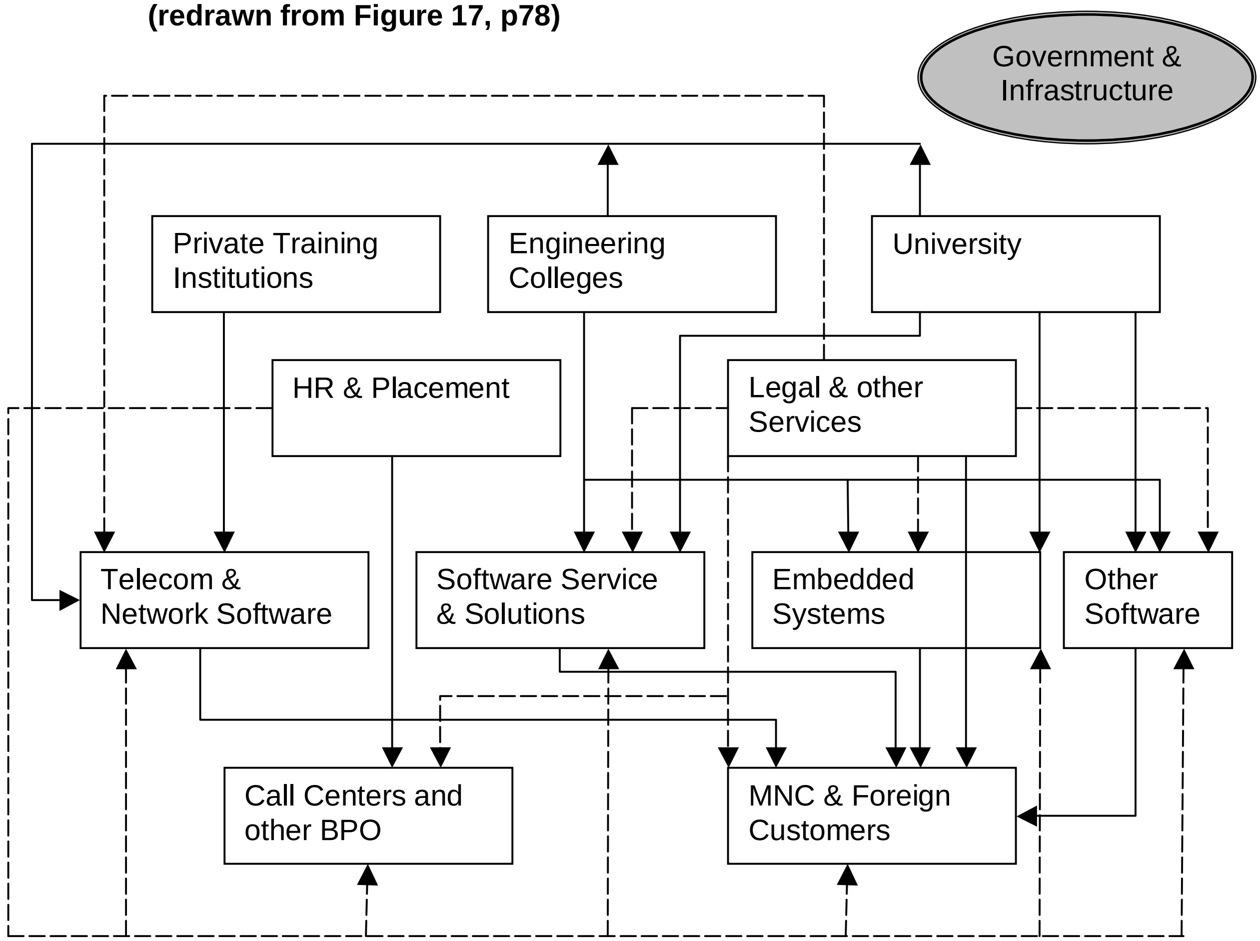
Source: Enhanced OECD Framework (OECD, 2000)

The study finds that, contrary to popular perception, the Government of India played a significant role in the success of this industry by stimulating the creation of clusters of excellence. That the impact was greater than was foreseen is a matter of circumstance. Policies were intentionally created and actions pre-meditated, and did not accidentally emerge out of “benign neglect”, as is popularly believed. This has practical implications for Governments of other developing nations who wish to develop their software industries.

The key limitation of this study is that it is specific to India. As a former British colony, the country has the legacy of the English language. It benefits from educational and legal systems instituted over the past five decades, a large personal network of world-class computer scientists of Indian origin in the US, and from a time difference of 8 to 12 hours from the major outsourcing nations. Some of these characteristics are entirely unique to India. Further, many of the policies enacted and investments made by the Government were within a very specific socio-economic framework that existed once and may not be replicable within the country or outside of it. These make generalizations difficult. Governments of other developing nations should examine the role played by the Government of India, and analyze the suitability of each policy initiative for their own country.

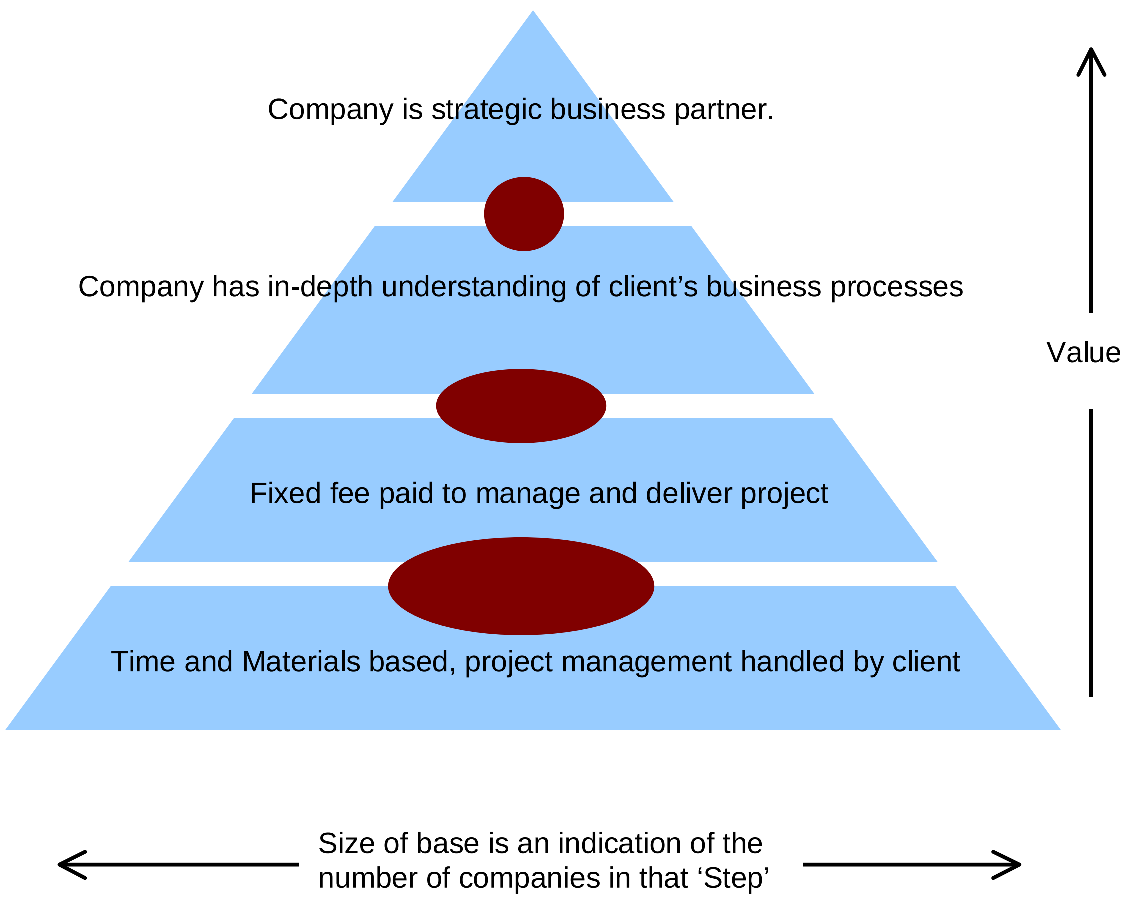
Specifically, the Government of India invested in education to make available the necessary human resources, incubated the industry to ensure its competitiveness in a global market, and set up the policy framework and information infrastructure required for the industry to succeed. Policies implemented since 1956 led to the creation of a skilled cluster of software companies with a reason to export software. The Software Technology Parks of India, an infrastructure and policy effort by the Government of India, made it easy to do business: a fundamental criteria for a cluster to emerge. Initiatives by the Government to free up skilled technical labour and entrepreneurial/managerial talent, as well as its widespread investment in education over decades, provided the human capital essential for these clusters to succeed. Through prudent Government contribution, the impetus was created, until the natural dynamic of the clusters kicked-in, accelerating the growth of the industry (see Figure 19).

Figure 19: The cluster that emerged in Bangalore, around the software industry (redrawn from Figure 17, p78)



Some words must be said to temper this enthusiasm. After all, while Arora *et al.* (1999) suggest that India has 16% of the global market in customized software, this number represents a miniscule fraction of the global software market. Unlike the US software industry that is driven by technology and product innovation, the Indian software industry measures itself by process maturity (SEI-CMM Level 5 is the target of most organizations in India). This creates a business with no true competitive advantage, since skilled labour is equally accessible by a U.S. company, as it is by a local company. Interviewees discussed the challenges of moving up the value pyramid. The key challenge appeared to be an inability to understand the client's market (directly related to the lack of a domestic software market), and therefore a limitation in the ability of the company to become a true partner. Companies that demonstrated a strong ability to understand their client's customer are better positioned to progress up the Value Pyramid (Figure 20).

Figure 20: Moving up the Value Pyramid (redrawn from Figure 8, p38)



When a relationship approaches the level of business partnership, it often results in an acquisition by the foreign client (Interview). It would be useful to study the different strategies adopted for moving up the value pyramid, in order that companies in the industry could learn and hopefully emulate such successes.

Positioning was also identified as a challenge: the tendency to associate "Indian company" with high quality and inexpensive services, but low quality products. Indian companies were said to be short of "marketing smarts" and have a mentality of developing software to meet an expressed requirement, rather than innovating by identifying an undiscovered need. India has never had a strong domestic market for software, and the Government has placed little emphasis on this over the years, driven by the foreign exchange earnings of an export-driven strategy. This is one key area where the Government can play an active role. Without a strong domestic market, product innovation is not possible. Unlike the car industry in Japan (for example), which has achieved international excellence largely due to a thriving and competitive domestic market, the Indian software industry has had to rely on an export-driven services-based growth rather than a product innovation approach. This limits its ability to move upstream, as well as the linkages of the industry with the rest of the economy. Unlike Silicon Valley, the software boom in India has not contributed much to overall productivity, and the government can do much more in this regard. Certain State governments (such as the Andhra Pradesh government) have initiated the use of software within the government sector. Measures such as the "IT Kiosks" in Andhra Pradesh and Karnataka where citizens can pay a variety of service fees (electricity, water, telephone) through a computer, result in a contribution to the overall economy in the nature of productivity increases. The domestic software sector unfortunately does not have the same glamour as the export sector (which was highlighted as part of the last Government's self-promoting campaign "India Shining"). Short-term politicking[37] is not supportive of policy implementation designed to support the domestic software industry.

There is little Government investment or private funding of graduate study programmes. Fernandes (2001) reports that the number of PhDs awarded in engineering disciplines fell from their high of 675 in 1987, to 375 in 1995. Grossman and Helpman (1991) suggest that countries

[37] In one conversation with a voter in rural Karnataka, it emerged that each of the two competing parties at the village level had given a saree (item of clothing) each to the lady and her daughter, and a bottle of arrack (unrefined alcohol) to her husband, in order to buy their votes. She regularly accepts these 'gifts' and proceeds to vote as she wishes!

like India can afford to pay less attention to high level engineering research because their form of innovation is the adoption of technologies produced in more developed economies. Consequently, there is a 60% vacancy in seats for post-graduate education in engineering (World Bank, 2000) in India. Even in the IITs, 60% of the seats for doctoral programmes in engineering are vacant, even as 450,000 people vie for just 2,000 seats at the undergraduate level in the IITs. This low enrollment in postgraduate programmes leads to a subsequent shortage of high-quality faculty, setting up a vicious cycle. Consequently, outside of a few niches, it is unrealistic to expect the growth of a product innovation process, or the development of a domestic market that drives a level of sophistication in product development that will in turn enable local software producers to export their products. In fact, seen in the light of the fact that the Indian Government's role began from the time India gained independence over five decades ago, other Governments may be best advised to develop their domestic software industry in order to reap benefits sooner; rather than imitate India's approach to the export market.

It will be interesting to explore, in a separate study, the following three questions:

1. How can India build a national competitive advantage for its software industry (or any emerging service industry) so that the country (rather than MNCs) reaps the benefits of its skilled labour?
2. What is the difference between service-oriented clusters (such as the software industry in Bangalore) and product-oriented clusters (such as the software industry in the U.S.)?
3. And a related question is: how can India's service-oriented clusters support an endogenous model of growth with linkages to the external community?

List of Interviewees

Academics

1. Dr. R. Natarajan, Chairman, All India Council of Technical Education (AICTE) and formerly Director, Indian Institute of Technology, Madras.
2 Dr. V. Rajaraman, Emeritus Professor of Computer Science, Indian Institute of Science, Bangalore; Formerly Chairman of the Technical Manpower Committee; Professor, Computer Science, IIT, Kanpur.
3. Dr. Ashok Rao, Head, Facilitation Unit, Center for Electronics Design and Technology (CEDT), Indian Institute of Science, Bangalore.
4 Cdr. Raman, Director, International Institute of Information Technology, Hyderabad.
5. Dr. Sadagopan, Director, Indian Institute of Information Technology, Bangalore.
6. Dr. K. V. Dinesha, Professor, Indian Institute of Information Technology, Bangalore.

Government Officials

1. Mr. K. P. P. Nambiar, Secretary to Government of India, Department of Electronics.
2. Mr. N. Vittal, IAS; Secretary to Government of India, Department of Electronics.
3. Mr. Lakshminarayana, General Manager (Rtd) Indian Railways (southern Zone)
4. Mr. J. Satyanarayana, IAS; Secretary, Dept. of IT&C, Govt. of Andhra Pradesh.

Industry Executives

1. Mr. J.A. Chowdary, CEO, PortalPlayer.com & President, Hyderabad Software Exporters Association (HYSEA).
2. Dr. S. Gopalakrishnan, Co-founder and Member of the Board, Infosys Corporation, Bangalore.
3. Mr. N. R. Narayanamurthy, Founder and Chairman and Mentor, Infosys Corporation, Bangalore.
4. Mr. D.V.S. Raju, CEO, VisualSoft Technologies, Hyderabad.
5. Mr. Sakthi Sagar, CEO, Wilco International, Hyderabad.
6. Col. M. Vijay Kumar, Director, Software technology Parks of India, Hyderabad.
7. Mr. S Ramanathan, CEO, Vanenburg Business IT Solutions, Hyderabad.
8. Mr. B.V.K. Mohan Reddy, CEO, Infotech Enterprises, Hyderabad.
9. Mr. Babu Atur, Managing Director, Mantra Broadband Private Limited, Bangalore.
10. Dr. T. Chokkalingam, MD, Infoniche Technologies Private Limited, Bangalore.
11. Mr. Vinay L. Deshpande, Chairman and CEO, Encore Software Limited, Bangalore; Chairman, Manufacturers Association of IT (MAIIT), India.
12. Mr. N. Krishnakumar, President, Europe and Asia, MindTree Consulting, Bangalore.
13. Dr. S. Yegneswar, CEO, Savantech Private Limited, Bangalore.
14. Mr. Kartik Prabhakara, Board Member, Purple Ace Wireless Solutions, India
15. Mr. Rajesh Reddy, Co-founder and CEO, July Systems, India
16. Ms. Nirupama V.G., GM India, Team Lease, Bangalore
17. Mr. Sabya Shree, Manager, Team Lease, Bangalore
18. Mr. Srimanto Bhattacharya, Co-founder, Spearhead Services, India
19. Mr. Chethan Elvis Das, Manager, Pristine Solutions, Bangalore
20. Mr. Nagendra Siravara, Vice President, Verisign India

References

AICTE: All India Council of Technical Education: http://www.aicte.ernet.in/

Aneesh, A (2000): “Rethinking Migration: High Skilled Labor Flows from India to the United States.” #18, Working Paper Series, The Centre for Comparative Immigration Studies, University of California, San Diego. Downloaded from http://repositories.cdlib.org/ccis/papers/wrkg18 (Last accessed January 2006).

Apte, Ravi (1998): “Software Export Development in the Global Context.” Electronics, Information and Planning, November 1988.

Arora, Ashish and Asundi, Jai (1999): "Quality Certification and the Economics of Contract Software Development. A Study of the Indian Software Industry." NBER Working Papers, NBER Website: www.nber.org/cgi-bin/author_papers.pl?author=ashish_arora (Last accessed January 2006).

Arora, A, Arunachalam, V.S., Asuni, Jai, Fernandes, Ronald (2000): “The Indian Software Industry.” Working paper No. 99-19, Heinz School, Carnegie Mellon University, Pittsburgh.

Arora, Ashish, Gamardella, Alfonso, and Torrisi, Salvatore (2000): “International Outsourcing and Emergence of Industrial Clusters: The Software Industry in Ireland and India.” SIEPR, Stanford University, July 2000.

Arora, Ashish and Athreye, Suma (2001): “The Software Industry and India’s Economic Development.” United Nations University (WIDER), Discussion Paper No. 2001/20, June 2001.

Bajpai, Nirupam and Shastri, Vanita (1998): "Software Industry in India: A Case Study." Development Discussion Paper No 667, December 1998, Harvard Institute for International Development.

Balasubramaniam, Ahalya and Balasubramaniam V.N. (1997): "Singer, Services and Software." World Development, 1997, 25(11), pp 1857-1861.

Balasubramanyam, V.N. and A. Balasubramanyam (2000): “The Software Cluster in Bangalore.” Regions, Globalization and the Knowledge-based Economy, (ed.) J.H. Dunning, London: Routledge, November 2000.

Baskerville, R., and Wood-Harper, A. T. (1998): "Diversity in Information Systems Action Research Methods." European Journal of Information Systems, 7 (2), pp. 90-107.

Bresnahan, Timothy, Gambardella, Alfonso, and Saxenian, AnnaLee (2001): “‘Old Economy’ Inputs for ‘New Economy’ Outputs: Cluster Formation in the New Silicon Valleys.” Industrial and Corporate Change, Volume 10, November 4, 2001, pages 835 – 860.

Business Week (2005): “India and China: What you need to know.” Asian Edition, August 2005, pp. 22-25.

Carmel, Erran (2003a): “The New Software Exporting Nations: Success Factors.” The Electronic Journal on Information Systems in Developing Countries (2003) 13, 4, pp. 1-12.

Carmel, Erran (2003b): “The New Software Exporting Nations: Impacts on National Well Being Resulting From Their Software Exporting Industries.” The Electronic Journal on Information Systems in Developing Countries (2003) 13, 3, pp. 1-6.

Chakrabarti, Alok (2001): “Universities and Industry Clusters: Observations from the US and Finland.” Working paper, MIT Industrial Performance Center.

Chakraborty, Chandana and Dutta, Dilip (2002): “Indian software industry: growth patterns, constraints and government initiatives.” Technical Report Working paper no 2002/06, available at www.rspas.anu.edu.au/papers/asarc/chakraborty.pdf (Last accessed January 2006).

Chandrasekhar, C.P. (2002): “The Diffusion of Information Technology and The Implications for Global Development: A Perspective Based on The Indian Experience.” Paper presented in the International Seminar on ICTs And Indian Development: Processes, Prognoses and Policies, Bangalore, 9-11 December 2002, Institute of Social Studies, The Hague and Institute for Human Development, New Delhi.

Crone, Mike (2002): “The Irish Indigenous Software Industry: Explaining the Development of a Knowledge-intensive Industry Cluster in a Less Favoured Region.” 42nd Congress of the European Regional Science Association (August 27-31, 2002). Available at http://www.erini.ac.uk/Publications/PDF/NiercConf2.pdf (Last accessed January 2006).

D'Costa, Anthony P. and E. Sreedharan (2004): "India in the Global Software Industry: Innovation, Firm Strategies, and Development." (eds). Palgrave Macmillan and Macmillan India Ltd.

de Fontenay, Catherine and Carmel, Erran (2004): "Israel's Silicon Wadi: The Forces Behind Cluster Formation." in Building High-Tech Clusters, T. Bresnahan and A. Gambardella (eds.), Cambridge, UK, Cambridge University Press, pp. 40-77.

Dedrick, Jason and Kraemer, Kenneth (2000): "Liberalization and the Computer Industry: A Comparison of Four Developing Countries." CRITO (UC Irvine) working paper available at http://www.crito.uci.edu/git/publications/pdf/4countries.pdf (Last accessed January 2006).

Desai, Ashok (2000): "The Peril and the Promise: Broader implications of the Indian presence in information technologies." Working Paper No. 70, Center for Research on Economic Development and Policy Reform, Stanford University, October 2000.

Economist, The (2005). "A survey on India and China." March 5-11, 2005.

Ein-Dor, P., Myers, M. D. and K. S. Raman (1997): "Information Technology in Three Small Developed Countries." Journal of Management Information Systems, 1997, Volume 13, Number 4, pp. 61-90.

EJISDC (2003): "The Emergence of Software Exporting Industries in Dozens of Developing and Emerging Economies", The Electronic Journal on Information Systems in Developing Countries (2003), 13.

Evans, P (1997): "Embedded Autonomy, States and Industrial Transformation." Princeton University Press, Princeton, 1995.

Evans. P. (1992): "Indian Informatics in the 1980s: The Changing Character of State Involvement." World Development, Vol. 20, No. 1, pp. 1-18.

Fernandes, Ronald (2001): “The Accounting of Human Capital Assets: The Case of the Indian Software Development and Service Industry.” Carnegie Mellon University, June 2001.

Fernandes, Ronald, Arora, Ashish, Asundi, Jai (2001): “Supply and Demand for Software Developers in India.” Carnegie Mellon University, 2001.

Fromhold-Eisebith, M (2001): “IT Means India’s Time.” in Vinanchi Arachi Jebamalai (ed.): INDIA’s Time. Essays in Honour of Murasoli Maran, Minister for Industry and Commerce, Govt. of India. Kadiroli Publications: Chennai 2002, pp. 72-92.

Ghemawat, P. and M Patibandla (1999): “India’s Exports Since the Reforms.” in Jeffrey Sachs A Varshney and N Bajpai (eds) “India in the Era of Economic Reforms.” Oxford University Press, New Delhi, 1999.

Green, Roy (2000): “Irish ICT Cluster.” OECD Cluster Focus Group Workshop, Utrecht, May 8-9, 2000.

Grossman, Gene M. and Helpman, Elhanan (1991): "Innovation and Growth in the Global Economy." Cambridge, Mass., MIT Press, 1991.

Hanna, N., Guy, K. and Arnold, E. (1995): “The Diffusion of Information Technology: Experience of Industrial Countries and Lessons for Developing Countries.” World Bank Discussion Papers, No. 2, 1995.

Haug, P. (1991): "The Software Industry in Washington State." Environment and Planning A, 1991, Volume 23, pp. 869-884.

Heeks, Richard (1995): "India's IT Policies: Liberalized or Not?" Electronics Information and Planning, pp. 655-666, September 1995.

Heeks, Richard (1996): "India's Software Industry: State Policy, Liberalization and Industrial Development." New Delhi: Sage Publications, 1996.

Heeks, Richard (1998): "The Uneven Profile of Indian Software Exports." Development Informatics: Paper #3, Institute for Development Policy and Management, University of Manchester, UK, October 1998.

Heeks, Richard and Nicholson, Brian (2002): "Software Export Success Strategies in Developing and Transitional Economies." Working Paper, Institute for Development Policy and Management, downloadable from http://www.sed.manchester.ac.uk/idpm/publications/wp/di/di_wp12.pdf (Last accessed January 2006).

Heitzman, James (1999): "Corporate Strategy and Planning in the Science City: Bangalore as 'Silicon Valley'?" Economic and Political Weekly 34:5, 1999.

Holstrum, Mark (1998): "Bangalore as an industrial district: Flexible specialisation in a labor surplus economy." in Philip Cadene and Mark Holstrom (eds) "Decentralized Production in India." Sage Publications, New Delhi, 1998.

Iwami, Motoko (2000): “Software Industry.” Research and Analysis Department, Japan Institute for Overseas Investment.

Jessop, Bob (1998): “The enterprise of narrative and the narrative of enterprise: place marketing and the entrepreneurial city.” in T. Hall and P. Hubbard, eds. “The Entrepreneurial City.” Chichester: Wiley, 1998, pp. 77-99.

Joseph, K.J. (2002): “Growth of ICT and ICT for Development: Realities and Myths of the Indian Experience.” Discussion Paper No 2002/78, WIDER-UNU August.

Kahaner, D. K. (1996): “Software Technology Parks of India (STPI).” Asia Technology Information Programme, September 1996.

Kaplan, David A. (1999): “The Silicon Boys and Their Valley of Dreams.” HarperCollins, 1999.

Kenney (2000): “Understanding Silicon Valley: The Anatomy of an Entrepreneurial Region.” Stanford University Press, 2000.

King, J.L., K.L. Kraemer, V. Gurbaxani, J. Dedrick, K.S. Raman, and C. S. Yap (1992): “Government Policy and Information Technology in Asia-Pacific Countries: A Conceptual Overview.” Informatization and the Public Sector, Vol 2, No. 2, IOS Press.

King, J.L., Gurbaxani, V., Kraemer, K.L., McFarlan, F.W., Raman, K.S. and Yap, C.S. (1994): “Institutional Factors in Information Technology Innovation.” Information Systems Research, 5 (2), pp. 139-169.

Klein, Heinz K. and Myers, Michael D. (1999): “A Set of Principles for Conducting and Evaluating Interpretive Field Studies in Information Systems.” MIS Quarterly Vol. 23 No. 1, March 1999, pp. 67–94.

Kohli (1989): "Politics of Economic Liberalization in India." World Development 17, no. 3, 1989, pp. 305-328.

Krugman, Paul (1991): "Increasing Returns and Economic Geography." Journal of Political Economy, University of Chicago Press, Vol. 99 (3), pp. 483-499.

Kumar, Nagesh and Joseph, K.J. (2004): “National Innovation System and India’s IT Capability: Are there any lessons for ASEAN Newcomers?” RIS-DP #72/2004, Research and Information Systems for the non-Aligned and Other Developing Countries, April 2004.

Leydesdorff, L. and H. Etzkowitz (2001): “A triple Helix of University-Industry-Government Relations and the Globalization of National Systems of Innovation.” Danish Institute for Studies in Research. Available at http://users.fmg.uva.nl/lleydesdorff/th_scientom/ (Last accessed January 2006).

Liu, N. (2001): "Task Attributes and The Employees' Knowledge Capture Behavior - An Empirical Investigation at the High-tech Industrial Park in Taiwan." Proceedings of the R&D Management Conference 2001, February 2001, Wilmington, New Zealand.

Lucas Jr., Robert E. (1990): "Why Doesn't Capital Flow from Rich to Poor Countries?" American Economic Review, 80(2), pp 92-96, May 1990.

Marshall, Alfred (1920): “Principles of Economics.” 8th edition, London: Macmillan (1st Ed 1890).

McKinsey (2001): “Programmers Abroad: A primer on offshore software development.” by Inigo Amoribieta, Kaushik Bhaumik, Kishore Kanakamedala, and Ajay D. Parkhe in The McKinsey Quarterly, 2001, Number 2.

Ministry of Human Resources, India: http://www.education.nic.in (Last accessed January 2006).

Mukhi, V. and R. Chellam (1998): “Software—an emerging business.” Business India, 28th September – 4th August 1988, pp. 124-151.

Mueller, Richard E. (1994): "Determinants of Economic Growth in Developing Countries: Evidence and Canadian Policy Implications.” Policy Staff Paper # 94/08, Department of Foreign Affairs and International Trade, Canada, April 1994.

Murphy, Kevin M. et al. (1991): "The Allocation of Talent: Implications for Growth." Quarterly Journal of Economics, 106(2), May 1991, p. 529.

Myers, M. D. (1997): "Qualitative Research in Information Systems." MIS Quarterly (21:2), June 1997, pp. 241-242.

NASSCOM: National Association of Software Companies, www.nasscom.org

NASSCOM-McKinsey Study Report (1999): available at www.nasscom.org

National Taskforce on Information Technology (1998): “IT Action Plan I, II and III”, “Background Reports“ and “Digest of Comments”. Available at http://it-taskforce.nic.in/

Oberoi, S.S. (1991): “Software Technology Park Concept, Procedure and Status.” Electronics Information and Planning, December 1991, pp. 142-144.

Oberoi, S.S and Raghunathan, G.V. (1991): “Indian Software Scenario.” Electronics Information and Planning, August 1991, pp. 603-606.

OECD Publication (2000): “A New Economy? The changing role of innovation and Information Technology in Growth.” OECD July 3, 2000.

Patibandla, Murali, Kapur, Deepak, and Petersen, Bent (2000): “Import Subsitution with Free Trade, Case of India’s Software Industry.” Economic and Political Weekly, April 8, 2000, pp. 1263–1270.

Patni, Ambika (1999): “Silicon Valley of the East.” Harvard Business Review, Cambridge, Fall 1999.

Porter, Michael (1990): “The Competitive Advantage of Nations.” London, Macmillan.

Porter, Michael (1998): “Clusters and the New Economics of Competition.” Harvard Business Review, Nov/Dec 98, Vol.76, Issue 6.5.

Rajaraman, V. (2000): “Information Technology in India—A retrospective (1965- 1999).” Computer Society of India Communications, January 2000, pp. 9-14.

Ramarao, P (1998): “Reshaping Postgraduate Education and Research in Engineering and Technology.” Review Committee of the AICTE on PG Education in Research and Development in Engineering Technology, GoI, pp. 126-127.

Romer, Paul M. (1986): "Increasing Returns and Long-Run Growth." The Journal of Political Economy, October 1986, 94(5), pp. 1002-1037.

Rosenberg, David (2002): “Cloning Silicon Valley, the next generation high-tech hotspots.” Reuters, Pearson Education, London, New York, Singapore.

Roy, Jayanta (2005). “India Looking Ahead: Two sides India’s economic miracle.” in The Financial Express, The Indian Express Newspapers (Mumbai), Ltd. 21 April, 2005.

Saran, R. (2005): "Factory of the World Meets Lab of the World." India Today, April 18, 2005, pp. 52-56.

Saxenian, A.L. (1994): “Regional Advantage: Culture and Competition in Silicon Valley and Route 128.” Cambridge, MA: Harvard University Press.

Saxenian, A.L. (2002): “Bangalore: The Silicon Valley of Asia?” in Anne O. Krueger (ed), Economic Policy Reforms and the Indian Economy, Oxford University Press, New Delhi, India.

Schware, R. (1992): “Software Industry Entry Strategies for Developing Countries: A ‘Walking on Two Legs’ Proposition.” World Development, 20, 2, pp. 143-164

Sengupta Jati K. (1993): "Growth in NICs in Asia: Some Tests of New Growth Theory." Journal of Development Studies, 29(2), January 1993, pp. 342-357.

Singh, Nirvikar (2003): "India's Information Technology Sector: What Contribution To Broader Economic Development?" Technical paper No.207, OECD Development Center, Paris.

Somerville, Ian (1992): "Software Engineering." 4th Ed., Addison Wesley, 1992.

Strauss, A. and J. Corbin (1998): "Basics of Qualitative Research." Sage Publications, Inc.

Stremlau, John (1996): "Bangalore: India's Silicon City." Monthly Labor Review, November 1996.

Tessler, Shirley, Barr, Avron and Hanna, Nagy (2003): "National Software Industry Development: Considerations for Government Planners." EJISDC 13, 10, pp. 1-17.

Transparency International (2005): "Global Corruption" report available on website: http://www.globalcorruptionreport.org/index.html (last accessed January 2006).

Tschang, Ted (2001): "The Basic Characteristics of Skills and Organizational Capabilities in the Indian Software Industry." Asian Development Bank Institute, February 2001.

Tschang, Ted (2003): "China's Software Industry and its implications for India." Development Centre Technical Paper, 205, Paris: OECD.

UIS (2005): UNESCO Institute for Statistics, www.uis.unesco.org (Last accessed January 2006).

Wallsten, Scott (2001): “The Role of Government in Regional Technology Development: The Effects of Public Venture Capital and Science Parks.” SIEPR Policy paper No. 00-39, March 2001.

Walsham, G. (1995): “Interpretive case studies in IS research: Nature and Method.” European Journal of Information Systems (4), 1995 pp. 74-81.

Winegardner, Karen E. (2001): “The Case Study Method of Scholarly Research.” The Graduate School of America. Available at http://www.tgsa.edu/online/cybrary/case1.html (Broken link, last accessed March 2003).

World Bank (1995): “Economic Developments in India: Achievements and Challenges.” The World Bank, Washington.

World Bank (2000): “Scientific and Technological Manpower Development in India.” The World Bank, Washington.

World Development Indicators Database (2005): http://devdata.worldbank.org (Last accessed January 2006).

Yin, Robert K. (1984): "Case Study Research: Design and Methods." New Delhi: Sage Publications, 1984.

Yin, Robert K. (1993): "Applications of Case Study Research." New Delhi: Sage Publications, 1993.