

THE INDIAN SOFTWARE INDUSTRY FROM AN ISRAELI PERSPECTIVE: A SYSTEMS/EVOLUTIONARY AND POLICY VIEW*

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INTRODUCTION

This *first* objective of the paper is an analysis of the evolution of Israel's high tech sector and cluster during the last 30 years & identification of aspects of Israel's IT hi tech experience of the 90s which may be useful to assess the prospects of India's IT hi tech sector during this decade. The *second* objective is to suggest policy directions or policy issues the tackling of which might contribute to accelerate the evolution, side by side with India's existing Software/IT industry, of a more R&D-intensive, 'Silicon Valley'- type segment of hi tech.

The objectives are strongly linked with three strands of the literature: the high tech cluster literature (Saxenian 1998, 2002; Breshnan, Gambardella & Saxenian 2002; & Avnimelech & Teubal 2002b among others); the Venture Capital (VC) literature (Gompers & Lerner 1999,2001; Dossani & Kenney 2001; Kenney 2001; & Avnimelech & Teubal 2002a,b among others); and various strands of the Policy literature, particularly Evolutionary/Systemic Innovation and Technology Policy (ITP, see Metcalfe 1996, Teubal 2002a, & Avnimelech & Teubal 2002 c). For our first objective we start by describing the two main phases of evolution of Israel's high tech industry, an initial R&D Penetration Phase comprising the 70s and 80s; and a Silicon Valley Phase which emerged during the 90s. Throughout we focus on two main co-evolutionary processes: a policy-business sector co-evolution process which spans both phases; and VC-SU co-evolution which is a main vector in the emergence of the second phase. Section 2 succinctly describes the two phases of Israel's high tech industry within such a Systems/Evolutionary perspective. We show that the first Electronics' dominated R&D Penetration Phase (1970-1989) was a *critical background condition* for the 'emergence' of a VC industry in the Silicon Valley Phase (decade of the 90s); and for the associated re-configuration of the Israel's high tech cluster to the Silicon Valley model (characterized by large numbers of SU companies, of VCs and strong links with global capital markets). In Section 3 we underscore the critical role that ITP played in both phases, including the *targeted VC directed policy* implemented in 1993-7. Whenever our analysis focuses on VC, and in contrast to most of the VC literature, it is concerned less with the *operation of an existing VC industry* and more with the process of *VC emergence* (A & T op. cit). Throughout, an explicit Evolutionary/Systemic approach to policy is undertaken. Thus we strongly emphasize the importance of 'learning processes' including learning by policy makers; the importance of considering not only R&D as an objective of

policy but also non-R&D factors such as issues of VC organization; the need for both incentives' programs and institutional changes (including aspects of liberalization and de-regulation); etc. Moreover, we refer to a number of co-evolutionary processes particularly VC-SU co-evolution (A & T 2002b) and ITP-Business Sector Co-evolution (A&T 2002c).

The most important implication for India is the possibility that the current Software Services phase of India's IT industry may be the basis upon which a Silicon Valley segment of IT high tech might emerge during this decade. Our basic thesis is that India is extremely well poised to enter into a 'Silicon Valley phase' of its IT industry one that will involve both further expansion of the existing Software industry & entry into new higher value added areas-part of the latter involving large numbers of SU and VC¹. This view follows from our analysis of the Israeli case and the conditions for it's, sometimes amazing, hi tech development during the last three decades. It also coincides with the predictions, implications or what can be surmised from the analyses of D & K op. cit 2002, Bowonder & Mani 2002, Business Week 2002 & B. Gates 2002.

A second implication for India of the Israeli experience is that materializing the above potential may require specific policy actions over and beyond the policies which have successfully been implemented in the past. Due to the need of rapidly achieving critical mass for collective learning & the rapid accumulation of the emerging segment's reputation; and as part of the effort of involving foreign Venture Capital at a much larger scale than previously-a *targeted VC-directed policy may be required*. Israel's Yozma program could be a model worth considering in this endeavor.

After considering the evolution of Israel's hi tech sector & of Israel's ITP (Sections 2-3) the paper summarizes findings from the field work conducted in Mumbai (Bombay) and Bangalore during September 1999 in which 19 Software companies and two 'Supporting Institutions' were interviewed. In Section 4 we focus on three companies which represent three different company types that could play an important role in the future evolution of the IT industry of India. One was an independently created Start-Up (SU) company; another, a large successful domestic

¹ The tremendous strides taken in the past by the Indian IT Software & Services industry are very well described in Nasscom 2002. This report also discusses India's prospects in these areas; and while it does analyze trends in Venture Capital it does not explicitly address the prospects for 'diversification' into the Silicon Valley model of high tech.

Software Services company; & the third, a Multinational company operating in India. A number of issues including policy issues emerge from these discussions.

The paper utilizes a framework of analysis which we recently developed to analyze Israel's high tech transformation of the 90s (A & T op cit) for extracting policy implications of potential relevance for India (due to the enormous complexity of the task we naturally hesitate to propose *specific* policy recommendations). As with the Israeli case, this paper utilizes both industry (or meso-level) information *and* microeconomic information and insights pertaining to hi tech companies.

The Importance of Micro-economic Analysis

Sectoral research oriented to policy and involving very dynamic sectors such as the Indian software industry require analysis at three different levels: a) firm (micro)-level, b) cluster/sector (meso)-level, c) policy level. Both the micro and the *meso* levels should, to some extent, be integrated into policy analysis for the latter to be relevant to reality. One implication is a multi-methodological perspective to policy-relevant research.²

Also from a “positive” analysis perspective (in contrast to a “normative” or policy perspective) sectoral/cluster analysis alone is frequently not enough; it must be complemented with a study of individual companies, particularly very successful companies whose direct and indirect (through spillovers) contribution to the cluster/sector and to the economy is high. Frequently the growth and transformation of a very dynamic sector is triggered by initiatives or pioneering efforts of firms (or individuals) who ‘show the way’. The path subsequently followed by the sector as a whole cannot, therefore, be understood without reference to those key firms or key agents.³ This has been the approach followed by Saxenian in her analysis of Silicon Valley dynamics—in that analysis a special role was played by firms such as Hewlett Packard (it created and diffused the so-called ‘HP-Way’—the culture of openness and informality both within the firm and beyond) during the period of ‘cluster emergence’; and by companies such as Sun Microsystems and specialized chip producers during the ‘cluster reconfiguration’ that occurred during the 1980s

² See Teubal 1999, Bartzokas & Teubal 2002, and Avnimelech, Gayego, Teubal & Toren 2000. The methodological implications of the last two items followed from an analysis of two segments of the Israeli Software and IT industries.

³ From a systems of innovation & evolutionary perspective we could say that such Schumpeterian firms/individuals introduce new ‘variety’ into the system being analyzed, which is then selected out by other agents, thereby initiated a cumulative development process. See Nelson 1995 for an analysis of evolutionary theory as applied to the study of economic and social change.

(Saxenian 1998). Such *key* firms not only were very successful in themselves but played ‘key’ roles for the cluster as a whole. They created a set of norms and values (the ‘culture of openness’); strategies, organization & business models (open systems, decentralization, outsourcing, etc); and promoted the creation of sector-specific institutions and organizations (e.g. business associations, link organizations with local governments; etc) with wide repercussions to the sector as a whole. A similar conclusion is arrived in a very dynamic segment of Israel’s software industry—the data security sector⁴. Four very successful companies out of a total of 19 comprising the sector in 1998 contributed a dominant share of total sector sales, profits and market capitalization (85-95%); and they also made very significant contributions to high-technology and to the economy. The Israeli study makes a clear distinction between very successful companies that remained indigenous (two out of four); and those who were acquired by multinational software companies (e.g., Computer Associates). Both the direct and the indirect contribution of the indigenous ones seemed to be higher than those acquired (T & A op. cit) This aspect of successful company growth might be of relevant for the Indian case, and might have policy implications as well.

2. ISRAEL'S HIGH TECH SECTOR AND CLUSTER: CHARACTERISTICS & EVOLUTION

Central Features of the High Tech Cluster of the 90s

During the 1990s the Israeli economy continued the process of structural change initiated in the seventies (Teubal 1993) but in an accelerated mode (Justman 2001). Within manufacturing (and probably within services) we observe a sharp increase in the weight of high-tech. The share of these industries in manufacturing employment increased from 14% in 1980 to 19.5% in 1998—a seemingly higher share than any OECD country (Avnimelech et al 2000, Table 1.1). IT High-tech sales & exports quadrupled or more from 1991 to 1999—from 3.6 B\$ & 2.2 B\$ respectively to 12.5B\$ & 11B\$; and the share of high- tech exports in total manufacturing exports, which has grown steadily throughout the last three decades,

⁴See Teubal & Avnimelech 2002b and Teubal, Avnimelech & Gayego 2002a. All the companies in the study were ‘product software’ companies although some(including two out of the four very successful one) were involved in ‘security services’ during the early phase of their growth

approximates 60%. Moreover, we see a sharp rise in the relative importance of the software and communications equipment segments (and lately, of Internet-related areas) and a relative decline of the more traditional electronics and instruments-based segments which characterized high-tech during the 1980s. Finally, the processes of globalization have generated a new type of export good—the sale of high-tech Start Up companies to foreign multinationals (this would be part of the process of Mergers and Acquisitions, M&A). This is a *sale of technological assets* rather than the traditional merchandise/services exports. It has become one of Israel’s most important categories of exports.

No less important than the quantitative hi-tech changes are the qualitative ones. Thus the high-tech cluster that emerged during the 1990s was very different from the military industries- dominated cluster of the 1980s (see Table 1 below). The changes include 1) large numbers of SU companies; 2) significant Venture Capital investments; and 3) strong links with the US-both product market links (e.g with Silicon Valley) and capital market links (e.g NASDAQ etc). These are elements of what can be termed the “Silicon Valley Model” of high-tech (Saxenian 1998).

Table 1: Israel's high Tech Cluster of the 90s

YEAR	99/00	90	80
Number of SU:	~3000	~300	~150
Number of VC Companies:	~100	2	0
Funds Raised by VCs: M\$	3400	~49	0
Capital Invested by VCs: M\$	1270	~45	0
Accumulated No of IPOs (high tech):	~150	9	1
Accumulated VC-backed IPOs:	~80	3	1
Share of Foreign Sources in Total SU funding:	67%	NA	NA
Share of IT Exports in Total Manufacturing Exports	45.7%	~33%	~20%
Capital raised in US capital markets during preceding decade B\$	~10	NA	NA
<i>Mergers and Acquisitions(M&A): B\$</i>	~10	NA	NA

Source: A & T 2002c. SU numbers come from three sources: CBS, OCS and IVA.

* Frequently the figures in the box are approximations due to gaps in data, multiples sources of information, and fragmentary information from non-official sources

Background Conditions⁵

The success of Israel’s high-tech ICT sector during the 1990s would not have been possible without the continued deepening of the globalization process during the last decade of the millennium and the continued ICT technological revolution. Globalization of technology and knowledge, organizational forms, capital markets, and skills created new opportunities which some countries more than others (or earlier

than others) happened to exploit due to their flexibility and capacity to adapt. Israel was one of the first countries outside the US which was fortunate enough to have exploited such opportunities, at least during the 1990s. In the early 1990s some US investment banks and private equity investment corporations came to Israel to search for high-tech investment opportunities. The subsequent government-owned Venture Capital Company, *Yozma*, was a result of an attempt at harnessing such behaviour for the benefit of Israeli hi-tech.

Israel's success with high-tech and its 'reconfigured cluster' seems to have been linked to a number of processes operating more or less in parallel. These include-

- The "Silicon Valley" model of ICT high-tech is *diffusing* to other countries;
- Strong links to US (and to some extent other countries') *asset and capital markets* were forged;
- Significant *foreign investments* into Israeli hi-tech, particularly in ICT areas, and including M&A (mergers and acquisitions) activity have occurred;
- Strong *personal, professional & business links* and networks have been forged between Israeli engineers, managers, investors and their counterparts in the US (to some extent also elsewhere).

The first one is a central feature of today's globalization process. The latter three are *proximate causes* of Israel's successful adaptation in the 1990s, i.e., of being one of the first Silicon Valley "model" offshoots beyond North America. They are explained by other *fundamental* variables such as -- availability of large numbers of high-level technical personnel (the numbers of engineers as a percentage of population is one of the highest worldwide), a pre-existing high-tech sector in the 1980s with at least moderate success; the existence of a set of country-specific institutions such as the Army research units; and strong revealed entrepreneurial capabilities (particularly at the SU phase of company growth, much weaker at subsequent phases). Other countries and regions in Europe and in the Far East are bound to follow suit and reconfigure their existing hi-tech clusters (or incorporate 'Silicon Valley' elements) e.g. India & Korea. There are a number of mechanisms explaining this diffusion process: 'imitation' and learning from others; enhanced cross border links; and enhanced selection pressures derived from the successful Silicon Valley model.

⁵ For a detailed analysis of the Israel's R&D Penetration Phase and of the Background Conditions setting the stage for the 'cluster

Capital Market Links

The proximate causes mentioned above co-evolved with the evolution of the high-tech cluster during the 90s.

Table 2: Number of IPOs of Israeli companies in US and EU capital markets

	All public Offerings			VC backed public Offerings		
	Number of Offerings*	Capital Raised (M\$)**	Number of IPOs	Number of Offerings	Capital Raised (M\$)**	Number of IPOs
79- 92	~30	~1000	~25	4	~60	3
1993	18	529	16	7	103	6
1994	10	336	8	5	35	4
1995	16	608	12	7	210	5
1996	31	1037	24	13	535	12
1997	24	1074	16	8	175	5
1998	14	907	14	5	144	5
1999	20	3172	20	16	1073	14
2000	36	2842	31	29	1530	24
2001	3	143	2	2	83	2
Total 90's	~202	~11200	~168	96	3950	80

Sources: A & T 2002c and website of Nasdaq, NASE, EU capital markets, Yahoo finance, and Globes Newspaper.

* Including IPOs, secondary and debt offering of all Israeli and Israeli related companies (high tech and none high tech) that are traded or were traded in NASDAQ

** US capital markets only.

A *central distinguishing feature* of Israeli hi-tech is the extent of integration with US asset and capital markets (this is not the case in other hi tech clusters of the 90s. e.g. those of Europe). Links with the US in many ICT areas and capital market links are critical both because of the size of the US market and because the US market sets the trend and pace of technological and market developments. Israel has been the country-not counting the US-with the highest numbers of IPOs (Initial Public Offerings) in NASDAQ after Canada and, till 1997 at least, its total number exceeded the cumulated IPOs at NASDAQ of all other countries combined (again, excluding Canada)⁶. Another instance of asset market links are M&A with US and other foreign companies, particularly acquisitions of small and young Israeli SU by US companies.⁷ Large chunks of Israeli ICT hi-tech seem to have been internationalized through this mechanism. M&As also comprise an important share of the growing flows of total direct foreign investment into Israeli hi-tech. Table 2 below gives information on public offerings of Israeli companies in the US between 1993-97 period.

re-configuration' of the 90s, see A&T 2000a,b.

⁶ See Blass and Yafe 1998.

⁷ In January and June 2000 the highest company values up to now were obtained from acquisitions of Israeli start up companies by foreign multinationals -- \$1.6 billion (Intel's purchase of IDPC); and \$4.7 billion (Lucent's purchase of Chromatis).

Importance of SU companies & Venture Capital

As mentioned the high-tech cluster of the 1990s becomes much more 'intensive' in Start UP firms (SU) and in Venture Capital companies (VC). Table 3 shows, year by year, trends in Capital Raised by VCs , Gross Additions to SU companies; and Gross Additions to VC-backed SU companies. We would like to emphasize a number of important points:

Table 3: Capital Raised by VCs and new SUs backed by Israeli VC firms

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Total
Capital Raised by VCs	58	160	372	374	156	397	727	675	1752	3288	1600	8559
NewVC backed SUs	10	20	80	90	80	200	219	252	338	513	221	1802
New SU	40	40	50	50	100	200	350	350	550	850	NA	2605

* Source IVA (statistics and estimates).

- 1) *VC emergence* i.e. the appearance of a distinctive VC industry—this took place during 1993-98 approximately⁸;
- 2) *VC- SU co-evolution*: starting in 1990-93 when we observe an excess supply of SU (i.e. unsatisfied demand for VC) followed later on by a sharp increase in VC capital raised and invested (the latter a *policy-induced* 'supply response'-see below);
- 3) *A targeted VC directed program (Yozma) triggered VC emergence and VC-SU co-evolution.*

A significant increase in SU numbers occurred during VC emergence- about 750 Startup companies were founded during 1993-7; and many more during the late 90s. Yozma funds are widely believed to have triggered a dynamic/cumulative process inducing industry entry by other private funds (both limited partnerships and other private equity companies); collective learning and other 'positive feedback' effects. The once and for all \$100M program had direct & indirect effects. The *direct* impact of Yozma is reflected in the growth of (gross) *accumulated* numbers of new VC-backed SU companies from 110 in 1993 to 730 in 1998. After 1995, the yearly flow of new SU is such that it exceeds the yearly flow of new VC-backed SU (thus reversing the situation of 1994 & 1995). This suggests an *indirect* impact of VC expansion namely an acceleration of SU formation. All in all we observe a sharp rise during the 90s in the proportions of VC-backed SU companies. Our thesis of strong VC-SU co-evolution (A & T 2002b,d) is consistent with this data.⁹

⁸ For a definition of VC emergence see A&T 2000c, p. .

⁹ Note that the vast increase in capital raised by VCs in Israel during 1999-2000 coincides with a tremendous jump world wide—the sums raised in the US for example jumped from around \$15 billion per year to over \$60 billion.

3. INNOVATION & TECHNOLOGY POLICY AND ITS IMPACT (1969-2000)

There are two distinct phases in Israel's R&D Strategy and possibly a third one (induced by the high tech crisis of the last couple of years) is emerging now. The first phase corresponds to the 'process of introduction and diffusion of R&D throughout the Business Sector'; the second phase corresponds to the emergence and development of a distinct high-tech cluster largely modeled on Silicon Valley lines (1990-2000).

3.1 R&D Penetration Phase (1969-1990)

The Israeli Government's innovation/technology policy towards the business sector began in 1969 with the creation of the R&D Industrial Fund at the recently created Office of the Chief Scientist (OCS) at the Ministry of Industry and Trade. This program was, and to some extent continues to be, the backbone of the country's R&D/innovation/technology strategy as far as the business sector is concerned. It supports the R&D of individual companies with the aim of creating new or improved products (or processes) directed to the export market. This type of R&D could be termed 'regular' or 'classical' R&D to differentiate it from generic, cooperative R&D, which is a more infrastructural type of R&D.¹⁰

The Industrial R&D Fund is an example of an *horizontal technology policy (HTP) program* that is a program directed to the business sector as a whole and open in principle to all firms in that sector—rather than to a specific industry or technology (programs supporting the latter would be *targeted programs*). These programs embody an important component of 'neutrality in incentives'. In Israel this expressed itself as a 50% subsidy to every R&D project submitted to the OCS, whatever the industrial branch the submitting firm belonged to; whatever the product class towards which the proposed R&D was oriented; and whatever the technology underlying such a product class (Teubal 1982, 1993). From \$2.5 million in the late sixties, the program involved disbursements which almost reached \$300 million in 1996/7¹¹.

¹⁰ The latter's objective is to generate knowledge, capabilities and components rather than directly marketable outputs. Its output would facilitate (or become inputs to) a subsequent 'regular' R&D activity directed to new products or processes.

¹¹ It is well known that horizontal programs embody an element of 'selectivity' by virtue of the particular activity being chosen e.g. regular R&D, generic-cooperative R&S, or technology transfer/adsorption. Thus Israel's "Industrial R&D Fund", while formally 'neutral' in the allocation of its incentives, and given its dominance over other programs for long periods of time, embodies strong selectivity of 'regular R&D' relative to other possible technological activities. See e.g. Lall & Teubal 1998.

Due to the central role played by the ‘Industrial R&D Fund’ Israel’s explicit R&D strategy or innovation/technology policy (directed to the business sector) in the last 30 years can be termed *an HTP-led strategy*. That program was the first of the set of programs comprising Israel’s program portfolio; and it was and still remains the dominant program in terms of government disbursements and probably(at least till the 1990s) in terms of impact. Moreover, the dynamic processes unleashed by its successful implementation led to the other programs comprising Israel’s innovation and technology policy of the last 10 years.

To understand the impact of the Industrial R&D Fund let us recall that the objective was *penetration & diffusion of ‘regular R&D’ throughout the business sector*.¹² While a neoclassical perspective would focus on the need to provide incentives due to market failure (caused by knowledge spillovers by firms undertaking R&D) an evolutionary perspective would focus first and foremost on the absence of R&D/innovation capabilities as a major obstacle to diffuse R&D. Initially, when first implemented, such capabilities were either non-existent or existent only in ‘islands’ within the business sector. Therefore *the major objective—during the infant phase of implementation- is to promote learning about R&D/innovation*¹³. Much of this learning is ‘collective learning’ that is R&D performing firms mutually learn from each other; and a lot of this learning relates not directly to technology or R&D proper but to organizational and managerial factors. Box 1 below illustrates some specific aspects of ‘collective learning’ during 1969-90 in Israel¹⁴.

BOX 1: COLLECTIVE LEARNING DURING THE IMPLEMENTATION OF THE “INDUSTRIAL R&D FUND”(first 20 years)
Firms learned about the importance of marketing (thereby overcoming the previously held view that “my invention is so good that it will sell automatically”
Officials and experts of the OCS learned, partly through exchange of information within and informal ‘policy network’ a) to better assess the quality and potential of the projects submitted; b) how to help firms configure good projects
Firms acquired capabilities for identifying new projects, including “complex” projects which built upon prior ‘simple’ projects

¹² Initial conditions in the ideal HTP model, which to our mind reflect the conditions prevailing in Israel in 1969, assume a) that R&D was practically non-existent within the business sector; and b) that its diffusion was a strategy priority of the country (a necessary condition for growth of the business sector and of the economy as a whole).

¹³ Learning, including experience-based learning triggered by increased R&D in the business sector, is *the* main factor leading to enhanced R&D/innovation capabilities.

¹⁴ Both are based on studies of Israeli hi-tech during the 1970s, see Teubal et al 1976 and Teubal 1982; (both reprinted in Teubal 1986).

Experience with Israel’s implementation of the Industrial R&D Fund showed that programs following a ‘learning/evolutionary’ a perspective would be facilitated by (or would require) the following:

- Assuring a critical mass of projects as early as possible (this is a condition for ‘collective learning’)
- Creating a policy implementation network—to assure learning by experience on the part of policy-makers
- Generating policy-relevant typologies of R&D pro/innovation
- Special attention might have to be given to promote wide diffusion of R&D
- Explicit attention to enhance policy capabilities
- Other: flexible budgets, use of grants rather than loans (and rather than tax concession, at least in the initial, infant phase of implementation); and bottom-up determination of projects.

The backbone regular R&D support program was widely regarded as having been a success in terms of stimulating R&D in the business sector, in stimulating exports resulting from R&D, and in contributing to the creation of a civilian high-tech sector during the 1980s (see Teubal 1993 op. cit., Toren 1990; and 1999, Justman and Zuscovitch 1999).

3.2 Expansion and Diversification

Successful implementation of the core or backbone program, *through an evolutionary/ dynamic process*, led to the emergence and implementation of a set of other programs in the early 1990s (see Program Sequencing Box 2 below).

BOX 2: PROGRAM SEQUENCING-ISRAEL
The successful implementation of Israel’s backbone “Industrial R&D Fund” program since 1969 led, together with other changes in the external environment, to a spate of new programs in the early 1990s,
1) Yozma (1992-97)—a \$100 million Government-owned Venture Capital company, which invested in 10 Funds which operated in Israel. Each fund had at least one major US investment bank/private equity investment company, at least one major local financial institution, and corporations/individuals (both domestic and foreign). Yozma, who triggered the emergence of a domestic VC industry, was privatized in 1997.
2) Magnet Program (1992-)—a \$60/70 million a year Horizontal Program supporting cooperative, generic R&D involving two or more firms and at least one University. Widely regarded as a successful program

3) **Technological Incubators' Program** (1992--)--a \$20/30 million a year program supporting entrepreneurs during the Seed Phase of their project, for a period of three years. The incubators are privately owned and managed. Both they and the projects approved get financial support from the Government. The program complements the Industrial R&D Fund (projects could be submitted to either program). It contributed to the transformation of Israel's high-tech cluster during the 1990s, particularly in the early years.

Throughout this period (the 90s) the regular R&D Grants of the OCS continued to grow, with grants from all programs reaching 440 M\$ during 2000 (see Table 4).

Table 4: Summary of Activities of the Office of the Chief Scientist (OCS) in 1997

Year	1987	1990	1993	1997	1999	2000
Number of Firms requesting support	~350	451	656	623	600	504
Number of first time Startups requesting support	32	34	179	170	138	126
Number of Project Support Requests- submitted	690	920	1513	1342	1316	1370
Number of firms Support Requests-approved	~300	352	474	479	486	488
Number of Project Support Requests-approved	580	670	1109	974	1007	908
Grants Approved	\$87M	\$137M	\$200M	\$397M	\$428M	\$440M
Royalties paid by companies	\$4.2M	\$14M	\$42M	\$103M	\$139M	\$134M
No. of projects in 26 Technological Incubators	0	0		212		

Source: Slide presentation of Chief Scientist, Dr. Orna Berry, 1999 & other OCS information

3.3 Israel's Targeted VC directed Program: Yozma (1993-7)¹⁵

Yozma is reputed to have triggered Emergence of Israel's VC industry. The spurt in VC activity that accompanied implementation of the program in 1993 gives credence to this view. It was based on a \$100 million fund (with the same name) oriented to two functions: a) investment in 10 private Israeli owned and managed VC funds –mostly Limited Partnerships('Yozma Funds'-\$80 million); and b) direct investments in high-tech companies-\$20 million. The basic idea was to promote the establishment of a domestic, professional VC industry. Each fund would have to involve a reputable foreign institution & a well-established Israeli financial. Funds' objective was *early phase investments in young Israeli high-tech start ups*. Once a fund fulfilled these conditions, the Government would invest (through Yozma) up to \$8 million -approximately 40% of the capital. Each fund also had a call option on government shares, at cost (plus interest) and for a period of five years. All this was supposed to create a solid base for the industry; to learn the business from foreign partners; and to access a network of international contacts. The Government was

¹⁵ See also Avnimelech & Teubal 2002c op cit.

willing to grant a bonus or premium to foreign institutions willing to invest in Israeli VCs despite the latter's lack of experience.

In total ten 'Yozma funds' were created-5 in 1993; 2 in 1994; 2 in 1995; and 1 in 1996. They managed \$310 million and invested in over 200 Start Up companies. They started a dynamic, cumulative process involving: learning by doing and imitation/learning from foreigners (this was a collective learning process); exploitation of economies of scale and specialization; and advantages brought about by consolidation of the overall new high-tech cluster in Israel (we could say the VC co-evolved with SU and with high-tech, more generally speaking).

An indication of their success in triggering growth of the industry is their expansion which took the form of 'follow up' funds. Each one of the Yozma funds (and some other funds as well, who indirectly learned from the Yozma experience) was followed by one or more additional funds managed by an expanding but related core of managers. The total sums managed by this group in 2000 approximated \$5 billion¹⁶ -- a large share of total VC industry funds¹⁷.

We conclude with the view that Israel's restructured 'program portfolio' of the 90s, and particularly the Yozma Program, had a strong impact on the growth of high-tech and on the emergence of the new 'Silicon Valley'/VC and SU-intensive cluster. Over and beyond Yozma's *direct effect* (as measured by e.g. the share of VCs with Yozma funds in accumulated VC capital raised) this assertion is based on the fact that the data is consistent with Yozma having triggered VC-SU co-evolution; on 'microeconomic insights' of entrepreneurs and policy makers; and on it being correlated with the strong growth of high-tech during the 90s. Since many other countries did not seem to have benefited to the same extent from the high tech product and technology capital market bonanza of the 90s, it is very likely that Israel's success owes a great deal to ITP, particularly to the *targeted VC-directed policy* which was implemented.

¹⁶ An expanded discussion of Yozma's impact and a systematic comparison between the Yozma and Inbal Programs can be found in A & T 2002c op cit

¹⁷ Yozma's successful implementation owes a lot to 'policy learning and experimentation'. The high rate of Start Up failure during the late 1980s led to a search for ways to solve the problem, including a visit of the Chief Scientist to Silicon Valley. The outcome was identification of what may be termed a 'systemic failure' in the country's national system of innovation—Venture Capital. For an expanded discussion of Yozma's impact see A&T 2002c op. cit.

4. ISSUES EMERGING FROM THE ANALYSIS OF THREE INDIAN IT COMPANIES¹⁸

Several papers have been written on India's software industry (Arora, NASSCOM 2002 op cit) and a summary of some of the important trends can be found in the introduction to this Volume. We will only mention some important facts. The Indian IT sector grew from 1.73 B\$ in 1994-5 (0.59 % of GDP) to an estimated 13.5 B\$ (2.87% of GDP) in 2001-2. 60% of the estimated level for 2001-2 involves *Software & Services* (around 8 B\$); & of these *Exports* are 6.217 B\$. Software and Services exports have consistently recorded a growth rate of over 50% between 1994-5 and 2001-2.

This section does not make use of industry level data nor does it perform yet another study of this kind. Its distinctive feature is a *microeconomic* analysis based on interviews of several companies and particularly an expanded write-up of three. Our presumption was (and still is) that numerous issues relevant to our analysis of the prospects of India's IT & Software industry could emerge.

19 companies were interviewed in Bangalore and in Mumbai (Bombay). They included large software services companies such as Wipro, Infosys, Satyam and Tata Infotech; a small number of 'entrepreneurial' companies involved in developing 'product software' such as SAS; (now Sasken) and subsidiaries of multinational companies (IBM, Hughes Software, etc). As with the Israeli study mentioned above and given the limitations of time and resources it was important after the interviews to focus on a small number of companies only.

The companies chosen were

- Wipro—from the group of large software services companies¹⁹
- Sasken---an entrepreneurial, product-software company
- Hughes Software-a foreign subsidiary²⁰.

¹⁸ This section is based on interviews conducted in the Summer of 1999 somewhat updated with information from Nasscom (2002). The policy issues and suggestions that emerged are relevant if global IT high tech product markets rebound in the next couple of years of so; and likewise with respect to global technology capital markets (NASDAQ).

¹⁹ Wipro is a Tier 1 player in the Software & Services industry. Following Nasscom 2002 op. cit , there are 5 such companies in India (defined as having an annual turnover of 200 M \$ or more) and they represent 33-35% of the overall software export market during 2000-01. These global companies offer a comprehensive services portfolio, boast a line up of *Fortune 500 customers*, and will continue to log in above industry growth rates during 2001-02. They include Tata Consultancy Services, Wipro Ltd, Infosys Technologies Ltd, HCL Technologies, and Satyam Computer Services Ltd. Spin-offs and spillovers from this group (and from somewhat smaller Tier 2 players) will contribute to the new model of hi tech discussed in this paper.

When reading the following accounts it must be realized that the objective is *not* to identify and measure a given set of variables or aspects across the three companies. Rather, by focusing on companies of different type, our objective is to further our understanding of how different segments of the existing IT industry might contribute to the new Silicon Valley type segment of the future. This and the constraints of interviewing time explain why *different* sets of variables were emphasized in each one of the cases.

4.1 Sasken

Sasken Communications Technology Limited is a leading provider of telecommunications software services and solutions to network equipment manufacturerers, mobile terminal vendors and semiconductor companies. Since its inception in 1989 Sasken has grown to be over 1000 strong with headquarters in Bangalore and offices in Canada, Japan, UK, USA and Sweden. It clocked revenues of 31.3 M\$ for the financial year ending March 2001 (Nasscome, op. cit p. 629).

This company is representative of an important category of software companies—an entrepreneurial, product-software company which was ‘independently’ born. Its seemingly ‘high quality’ probably situates it within a small class of potentially future large, global companies. The founders had extensive experience in Silicon Valley and decided (a team of four) to leave their jobs in 1989 and come to India to set up a company to design and build a front end tool for VLSI design. At some stage in the development of the company it got involved in DSL(Digital Subscriber Lines) products, developing a PC-based solution. The development process involved explicit participation in the relevant international standards’ committee where the company acquired market/need knowledge, reputation, and links with potential partners—all of which contributed to what seemed to be a successful product. The company had in September 1999 around 500 employees of which 440 were technically qualified (50% had Master’s degrees in computer science and in electronic engineering; and there are twenty Ph.D.s)

We group the issues that emerged from the interview into four categories.

²⁰ For the content of the interviews see Teubal 2002b pp155-6.

1) Strengths of the Indian software/ IT sector (which favored the firm)

Sasken's successful development was favored by a number of characteristics of the Indian context and by the globalization process. These include: (1) Silicon Valley experience of founders (this is indicative of a least a measure of personal and professional links between the Indian system and Silicon Valley); (2) High quality research universities (Indian Institutes of Technology)—from which both professors, students and graduates were drawn to the firm; (3) The attractiveness of India to multinationals such as Nortel who was looking for outsourcing of its R&D towards the mid-1990s.²¹

2) Benefits from Globalization (favorable to Indian companies like Sasken)

These include the possibility of participation in the Standards Committee relevant for the ASDL technology it was developing (this possibly reflects the openness of the international system in the sense that Indians can participate in some 'global' institutions. It also reflects a measure of maturity in the Indian software cluster in the sense of being able to exploit such feature of the world system). The above not only enabled adaptation of local efforts to ongoing developments including those of 'complementary' technologies and products, but also generated important links with key players in the area. It set the base for subsequent agreements with Intel (and directly or indirectly probably with other companies as well)

3) Weaknesses of the software/IT cluster or system

In parallel with the undoubted academic excellence in science and engineering, there was a felt need for a stronger practical orientation of at least part of the academic institutions. Moreover, there seemed to have been insufficient interaction between government labs (including defense labs) and business (this is a reflection no

²¹ Nasscom op. cit (p.32) lists a set of 'factors of strength' of the Indian IT industry, some of which are important for generating a future 'capability' for creating hi tech SU companies and a 'product' software, R&D based IT segment. The current factors of strength include: cost value proposition ;vast base of English speaking, skilled manpower;high quality orientation (major expansion in base of ISO and/or SEI CMM level 5 companies); experience and state of the art hardware and software platforms; flexibility and adaptation of Indian professionals for on-time, on schedule delivery of projects; high reliability factor of Indian software export companies; strong educational orientation (perfect for producing high class engineering graduates skilled in computer sciences and engineering); a vast base of Fortune 500 customers who are increasingly outsourcing in India; and support from successful Indians in Silicon Valley. To this we could add Government incentives e.g. tax incentives to software exports.

less of future potential as it is of current weakness). The globalization of asset/capital markets of the 90s had not yet affected the company by 1999 –no foreign Venture Capitalist seems to have invested in the company; nor was any IPO undertaken.²² At the time only large companies seemed to have an opportunity of undertaking an IPO in global markets. One possible cause was insufficient Venture Capital funding and the relatively underdeveloped VC industry in India at the time. A final point is that the firm was only weakly linked with knowledge networks at the time. This was considered by the firm as an important obstacle for innovation success (a possible *System Failure* in India).²³

4) Policy Issues Addressed by the Interviewee

The main point here was the significant felt change in the attitude of the Indian government towards the software industry after 1996—the government was now (1999) speaking the language of enterprises like SAS. However there were still many areas of 'need' where policies did not provide answers or were non-existent e.g. *seed finance* (where the interviewee was looking forward to some action in this area e.g. incubators); *the Supporting Structure* e.g. educating more practically oriented graduates; changing the governance of institutes/universities to enable and induce researchers to create/manage/own companies, etc; and *promotion of business-university links*.

5) Other Policy Issues

The interview with Sasken suggested a number of potentially relevant policy issues or policy directions. The most important point is the *desirability of continuing with a targeted policy favoring the Software & IT industries* in which India has a clear competitive advantage in world markets. However other elements in the overall policy portfolio or package may be required. Up to now the package involves 'framework conditions' and infrastructure (e.g. Electronic City in Bangalore); liberalization²⁴; & means to reduce bureaucracy. Two other policy objectives suggested by the Israeli

²² Although there seemed to have been some investments by another company or some private placements. Israeli counterparts to SAS e.g. Orkitt, have actually benefited from IPO and from investments by foreign and local financial institutions (including Venture Capitalists).

²³ Participation in the Standards Committee mentioned would be one means of getting plugged into world knowledge networks. Also Venture Capital could play a role in this respect. Finally, it must be mentioned that knowledge links build up gradually and cumulatively as a result of expansion of the firm and of the industry as a whole.

experience are *the support of R&D/ Innovation* (e.g. through a grants or conditional loans scheme); & the *Support of Venture Capital*. The Israeli experience also suggest that at the current stage of the Indian IT high tech cluster the support of R&D/Innovation should be considered as complementary rather than substitute to targeted support of Venture Capital. Both would be *strategic priorities* since both promote entry of SU into the branded, software & IT 'product' segment of hi tech.²⁵

Conclusion: The Sasken experience suggests that, given the existence or the potential for generating large numbers of very good SUs, certain components of the Silicon Valley 'model' might be relevant for India (e.g., a well-developed VC industry involving domestic and/or foreign funds). On the other hand, it suggests that the existing national/regional setting is such that explicit policies -including innovation/technology policies & targeted VC promotion policies- could accelerate the above-mentioned evolutionary process.

4.2 Hughes Software Systems

Hughes Software Systems (HSS) specializes in convergent network software and is the number 1 communications software company of India. Assessed at SEI-CMM level 4 for all its development centers and all projects, HSS has been an ISO 9001 company since 1996. It has a team of 1500 world class professional at its development centers in India (Nasscome 2002 op. cit p. 362).

The company was created in 1992 as a subsidiary of Hughes Network Systems which is a joint venture of Hughes Electronics and General Motors. The reason for establishment of the subsidiary was similar to those underlying the decisions of other Multinationals—particularly the availability of skilled labor at very low costs compared to the cost of such labor abroad. At that time Hughes held 76% of the shares while a group of Venture Capitalists held the remaining 24%. The focus of this company was software services and a large proportion of sales were directed to the parent company.

²⁴ A detailed discussion of the liberalization and de-regulation steps taken during the 90s can be seen in D & K 2002 op. cit. Their analysis shows, that despite the undoubted advances, important obstacles still remain (at least till the last couple of years).

²⁵ It is a major issue whether or not India would like to implement an 'incentives' program in support of R&D/Innovation. While such programs could make a significant contribution to the high tech cluster, its effectiveness would depend on good design and non-bureaucratic, learning-enhancing implementation.

In 1996 a group of employees suggested to the management of Hughes a change in strategy which would contribute to their motivation to stay in the company by responding to their desire to become 'business persons'. This included the development of 'product' software (or at least software modules) for the market rather than services to a single customer. The company's management responded positively and a change of strategy took place. In this context it undertook an aggressive marketing strategy during 1998-99 while struggling to get out of a purely 'engineering' perspective—and US customers were beginning to buy. By September 1999 over 50% of sales still went to a single customer, but the goal was to reduce it to 25%. Subsequently the company became the first multinational in IT to go public in India (Mumbai Stock Exchange, during October 1999), and the share of Hughes was diluted to 56%.

Possible Lessons or Implications of the Case

The above points out to a situation where an MNE can directly and indirectly contribute to the eventual emergence of an Indian (or largely Indian) company involved both in developing 'product software' and in downstream 'marketing' activities. An important condition suggested by the Hughes case is the existence of a strong, domestic stock market (which is the case in India, see D &K op cit) where the MNE subsidiary could float shares. It suggests the existence of an important mechanism in India for further developing and 'reconfiguring' the existing software and IT cluster. The mechanism usually mentioned in the literature on high tech clusters focuses on the market/management/technological spillovers and spin-offs from MNEs (Breshnahan, Gambardella & Saxenian, 2002). These are very strong in Israel & presumably in Ireland; and will become even stronger in India given the frantic activity of MNEs to create R&D facilities in India (Business Week 2002). What a strong domestic capital market can give in addition to spillovers is a mechanism for the restructuring of MNE subsidiary itself, a process leading to a mixed pattern of ownership (both foreign and domestic ownership); and to a new set of activities and an increase in the scope and variety of spillovers (over and beyond that which might come from an MNEs lab).

More specifically, the restructuring of Hughes enhanced the accumulation of market/marketing/client-related assets, which is a richer set of spillovers compared to what seemed to be dominance of engineering-related spillovers in the original phase after establishment of the subsidiary (frequently MNE subsidiaries which undertake

R&D generate a lot of technological spillovers and much less market and client-related spillovers). It follows that if future priorities of the Indian software & IT Industry involve (a) a vigorous development of software & IT products and venture capital; and (b) emergence of a segment of indigenous companies with high growth rates and eventual global status---then, the above-mentioned partial shift to product software *and* accumulation of client/marketing/market-related and reputation assets which follow the change in ownership-- could be helpful for the next phase in the development of the industry^{26, 27}.

Conclusion

The Hughes case together with the framework of analysis which emerged from our Israeli study suggests two possible mechanisms for generating global indigenous companies in IT ‘product’ areas: (1) the '*Israeli pattern*' which is based on the existence of large numbers of hi-tech SU companies and on a system which, during the 90s, facilitated a small subset of very good companies to undertake IPO in NASDAQ rather than to be acquired very early by a foreign multinational (see Teubal & Avnimelech 2002a,b); and (2) the *Hughes example* which suggests that pre-existent MNE which populated the first phase in the development of the Indian software industry, through floating of the local subsidiary in the domestic capital market, may eventually become or increasingly behave like an Indian company while simultaneously diversify into ‘product software’ areas. I suggest that both mechanisms should be explored and policy implications unraveled. Note that while the latter mechanism might be a real possibility in India without major changes in its system of innovation, the former Israeli- type mechanism for generating ‘indigenous companies’ in India would require a ‘system’ with Venture Capital and large numbers of SU companies(see the Sasken case above and the inferred policy implications).

4.3 Wipro Infotech

The company is part of a large conglomerate one of the largest in India, and is one of India’s largest software companies. The conglomerate made a decision to enter the IT area in 1980, due to restrictions on imports of minicomputers. At that time only

²⁶ The importance of ‘indigenous’ global companies for a balanced accumulation of assets is also borne out from the study of very successful companies in the data security industry of Israel. See Teubal & Avnimelech 2002b op. cit.

²⁷ The Hughes example might also contribute ‘indirectly’ to the next phase of development of the Indian software & IT industry –by representing a strategic/organisational/business model that could happen within other MNEs.

larger categories of machines such as mainframes were allowed, so the possibility of producing minicomputers arose. Wipro developed, in its first phase strong skills in hardware design, and had a clear growth objective which involved both proprietary products, distribution partnerships, and an explicit building-up of in-house expertise. It became the No 1 vendor in the country offering multiple products.

The company entered the software business in 1989 initially with a strategy for developing 'product software' which failed (due to marketing reasons). It then reoriented to software services including the creation of an Offshore Development Centre where development was undertaken for companies like Nortel & General Electric. Later on, it started to offer integrated software/hardware design services. Some product development activity has also been undertaken, but this represented (in 1999) a minor share of the company's activity.

Total sales in 1998 were \$350 million, of which \$100 million were hardware and the rest divided among two software groups: the software and software services group; and the systems and services group (both are independent groups within Wipro).

Future (post 1999) Activity

The next phase would involve going up the value chain, e.g. fixed price transactions for the development of Application Software; specialization in vertical segments such as finance, retail, etc; and the development of some re-usable software components which may represent building blocks for large software projects of clients abroad. They represent system integration, solutions development & operations support activities of a higher level of sophistication compared to the past. Till September 1999 there seemed to be no plans of entering even more sophisticated consulting business such as IT consultancy or business processes consultancy.

Possible Implications

The case of Wipro suggests that large opportunities do exist in India for the continued growth of software services and customized software, up the value chain, and that this will continue to be for a long time, the basis for the growth of the Indian software industry.²⁸ Moreover, given Wipro's ownership of a Silicon Valley company and a one- shot transfer of technology to another company there, the case suggests

²⁸ This has been confirmed by the very fast growth that took place after 1999

how large Indian software companies could-indirectly or directly- promote the development of SU in the IT and software areas , and even of Venture Capital. The later would be a strong effect if spurred by a change in Strategy e.g. in response to changes exogenous to the company.

The mechanisms by which large domestic incumbent companies may contribute to the new segment of IT high tech include: (1) Undertaking product-software development activity with or without spinning it off as an independently managed subsidiary (probably in conjunction with other companies and/or investors) or joint venture; (2) personnel spin-offs --including managers--which found or join SU companies or VC companies²⁹; (3) investment in Indian SU companies; (4) agreements or partnerships with SU companies

Implementing the above involves important strategic and organizational issues for the large, services-oriented software company. These, in turn, could be more or less stimulated by Government policy—both incentives and ‘institutional changes’ (stimulation of VC—of corporate VC funds as well as limited partnerships, direct support to R&D; taxation issues; bankruptcy laws, corporate governance, regulation of financial markets, regulation and taxation issues connected with M&A, etc).

5. PROSPECTS FOR INDIAN IT & POSSIBLE POLICY IMPLICATIONS³⁰

Prospects of Indian IT industries

Our analysis (here & in A&T op cit) of the emergence and development of a venture capital Industry in Israel and its role in the recent successful growth of Israel’s high tech cluster suggest the important role played by five (5) groups of factors, events or sub-processes: (1) *favorable background conditions*; (2) events or features of the *immediate pre-emergence period (1989-92)*; (3) *Targeted Policies* which directly triggered VC Emergence (1993-6/7); (4) The onset of a *complex, cumulative dynamic process* including multifaceted 'Collective Learning' & strong VC-SU co-evolution; and (5) *Global Capital Market Links* (IPOs & M&A)³¹. Israel's evolution towards a (or pattern of emergence of the) Silicon Valley model of hi tech

²⁹ An example is the VC Company founded by the founder of Infosys- among India's leading software companies. Also, the high quality links between large Indian Software Companies and large Multinational Corporations also facilitate the identification of the 'technology needs' of the latter. This could potentially be a very valuable asset, one that spurs the process of SU formation in India.

³⁰ The analysis which follows presupposes that the global IT high tech market will recover in the next 2-5 years or before.

³¹ The emergent properties of the re-configured high tech cluster were: A VC market/sector comprising large numbers of SU & VC; an increasing weight of SU 'output' in total high tech output; & strong links with Global Capital Markets

was based on spurring VC-SU co-evolution through a targeted, VC directed program implemented during 1993-7(Yozma).

Favorable background conditions included the prior existence of an Electronics Industry who had developed during the 70s and 80s both R&D/ Innovation capabilities & links with the US; a large pool of skills; a process of liberalization and improvement in the business environment; and other favorable external and internal conditions. Moreover during a pre-emergence period (1989-92) VC (partly non-formal) or proto-VC activities already existed as well as significant numbers of SU who represented *an unsatisfied demand or need* for VC services. Finally the design & timing of Yozma was such that it led to the early and rapid accumulation of reputation & capabilities.

Our central point is that, despite the obvious differences between Israel then and India now, there are similarities in these two countries in terms of *favorable background* conditions for the emergence of a software/IT segment of hi tech with Silicon Valley characteristics. Partly as a result of a *targeted* policy implemented during the 90s India presently enjoys a comparative advantage in the Software & IT services industry which will enable it- with the help of other internal and external factors-- to create 'advantages' in other segments of IT including branded software products & high tech SU companies (see above p. 16, footnote 21). This possibility is real. Some of these factors parallel those operating in Israel during the late 80s-early 90s: large quantities of high quality & low cost graduates in IT (over 220,000 software and computer science engineers graduates every year, see Business Week in 2002); the success & reputation of the existing software & services industry (13.5 B\$ estimated output for 2001-2); the existence of highly reputable large software companies which, despite being overwhelmingly involved today in high quality and highly reliable customized software applications/software services, could contribute directly & indirectly to the new IT segments; & web of personal linkages with Indians working in Silicon Valley and elsewhere(see D&K 2002, & Saxenian 2002). Moreover as the case of Sasken and other successful high tech R&D intensive SU demonstrates, there already exists a measure of innovation and high tech entrepreneurship capabilities in the Indian scene (Saxenian 2002, pp 142-3).

In addition, to some extent favorable *pre-emergence conditions* seem to have appeared in India towards the late 90s. These include a significant increase in Venture

Capital and of VC organizations which are private & foreign owned³²; the apparent disposition of increasing numbers of NRI to come to India to search for (and invest in) projects; etc. We are less sure about other factors which we considered important in our analysis of the Israeli case: creation, prior to emergence, of large numbers of SU which represent *demand* for the services of a VC industry expected to emerge a few years later (in Israel this was induced by specific policies); policy experimentation and learning—which can set the base for further refining and complementing the existing package or portfolio of policies directed to the Software/IT industries; and further improvements in the institutional and business environment. Moreover it is not clear to us to what extent a mechanism has been put in place to systematically support SU & business sector R&D and, indirectly, the accretion of R&D/Innovation capabilities (at least till Venture Capital could take over most of this function). It is our belief however, that both public and private agents in India are (or will) find solutions to the above & other problems.

Still, the transition requires the onset of a strong, cumulative process of growth of 'product' software & IT hardware—with a potential vector being SU-VC co-evolution. True that the existing IT/Software industry (particularly large Software incumbents and R&D lab subsidiaries of MNEs) could be a spring board for the emergence of such a segment e.g. through spin-off companies, technological, market/ marketing & managerial 'spillovers'; networking & reputation effects; investments in new ventures or in VCs, etc. Despite this possibility, *the onset of a cumulative, self-reinforcing process may require a more focused policy than that which has been undertaken -till at least 2-3 years ago* (this is also consistent with the view held by D & K 2002). The Israeli experience would suggest that such a complement of targeted policies could trigger the above cumulative process and assure its continuation by assuring critical mass in a short period of time. Moreover, policy may also be required to further reinforce the pre-emergence conditions mentioned in the previous paragraph.

³² In a previous work (A & T 2002c) and following D&K 2002 we point out the significance of some of the positive developments in India's VC industry during the 90s. This is reflected also in Nasscom op cit (p. 119-20) which points out the comparatively large amounts of funds invested & the minimal reduction in VC investments during 2001-02 compared to 2000-01 (1.1 B\$ against 1.2 B\$); and to the fact that over 70 VC funds were operating during 2001-2 with total capital management of 5.6 B\$. The data however is not clear about the *structure & organizational forms of VC funds/companies*, nor about the share of investments which are *'early phase investments'* a critical aspects of the Silicon Valley model of high tech. For this reason it is not clear to us whether *VC Emergence* -in the sense of a *cumulative process of growth* taking place in Israel's VC industry during 1993-8--has really taken place (probably not). For further insights in India's VC industry see Bowonder & Mani 2002.

Policies Supporting Software/IT transformation

Under a Systems/Evolutionary perspective to ITP (Teubal 2002a) a fundamental distinction should be made between a) *strategic priorities* on the one hand (the outcome of the ‘strategic dimension’ to innovation & technology policy which starts with a *vision & a strategy* to achieve it); and b) their *translation into a new or restructured set of incentives programs and set of institutional changes*. The *vision* for India's future Software/IT industry could include first-continued growth in existing services/ customized software areas & accelerated entry into higher value added activities; & second-emergence and development of a thriving, competitive, R&D-based product software & IT hardware segment of hi tech.

The strategy or strategic priorities to achieve the above vision could include - 1) creation of large numbers of SU companies in product software areas—hundreds every year; 2) reinforcement of the domestic, *early-phase oriented* Venture Capital industry with characteristics similar to those of the US and Israel; 3) Assuring a mutually supporting process of VC-SU co-evolution³³; 4) Assuring the effective transition of SU from the R&D to post R&D phase and emergence of a subset of high-growth SU companies(‘gazelles’) & of a set of large domestic companies in the software products area which have acquired world status; & 5) facilitating enhanced links with global capital markets, particularly NASDAQ.

We propose two axes to the new elements or components of the package of policies that could be applied. The first, a set of incentives programs whose objective is to trigger and sustain VC-SU co-evolution; the second, liberalization, de-regulation and institutional changes. The *raison d’etre* of the former is our presumption that the most adequate way for VCs and SU companies to be created is for them to *co-evolve*. This means transforming their creation into a strongly *endogenous* process. The role of policy in this context would be to trigger this process of co-evolution & to sustain it for some time (till full endogeneity is achieved i.e. without government inducements). Note that achieving this strategic priority may require the implementation of more than one incentives’ program e.g. a *targeted* VC-directed program and another program directly stimulating SU creation and growth (in Israel this function was performed by

³³ Co-evolution may mean three things: 1) that it is very difficult to trigger the process because of a ‘chicken and egg’ problem; 2) coordination among tools and issues of timing are critical (Teubal & Andersen 2000); and 3) that once the process is ongoing, cumulative reinforcement will ensue. This is a main reason for adoption of the systems of innovation rather than a simple neoclassical/structuralist perspective to policy.

'horizontal' R&D grants to the business sector -which did not discriminate against small companies; and by the Technological Incubators' program).

The second axis is a group of policies aimed at creating a favorable Business Environment for the new Software/IT industry segment. Following D &K op. cit and others this should include both 'general' liberalization (including the gradual assurance of currency convertibility) & further de-regulation of the VC industry. Our experience suggests also that attention may have to be given to other aspects of the institutional framework e.g. corporate law/governance, etc.

We hope that these comments are useful to Indian policy-makers.

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