

OBSERVATIONS ON THE INDIAN SOFTWARE INDUSTRY
FROM AN ISRAELI PERSPECTIVE: A MICROECONOMIC
AND POLICY ANALYSIS^{1*}

Morris Teubal

The Hebrew University of Jerusalem (Economics)

msmorris@mscc.huji.ac.il

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INTRODUCTION

The objective of this paper is a preliminary analysis of the Indian Software Industry with a focus on some selected microeconomic aspects of the sector, so as to raise possible policy issues from a comparative perspective and to explicitly relate to the experience of Israel—both from its promotion of business sector R&D and from its efforts at transforming high-tech industry during the 1990s. And secondly, to generate some more fundamental research questions which could then set the base for a wider and more significant research agenda (including an agenda for future *policy-relevant* research).

The paper summarizes some of the findings of field work conducted in Mumbai (Bombay) and Bangalore during September 1999 in which 19 Software companies and two ‘Supporting Institutions’ were interviewed. I focused on three companies where each one represents a company type that could play an important role in the future evolution of IT in India. These are—independently created Start Up (SU) companies (the one interviewed had successfully evolved beyond the SU phase); large, successful Software Services companies; and Multinational companies. A number of issues including policy issues emerged from these discussions.

The paper then presents in a succinct fashion the central elements of Israel’s high-tech industries, in particular its evolution during the 1990s when a number of features of the “Silicon Valley model of Hi-tech” were adopted. It starts by briefly considering the background conditions which led to this process—diffusion of the Silicon Valley model and globalization of asset/capital markets. It then proceeds to characterize the Start Up and Venture Capital phenomena within a broad, dynamic-evolutionary

perspective. Finally, it considers the Israel's R&D or Innovation/Technology Strategy by considering two phases—the first phase of diffusion of R&D/innovation within the business sector (1969-1990) induced by a 'backbone' horizontal program supporting 'regular' R&D by extending grants directly to individual enterprises on a per-project basis; and the second phase (during the 1990s) where a diversification & expansion of the program portfolio took place. In this latter phase a targeted program supporting the emergence of Venture Capital (VC) –Yozma—was implemented, together with two or three additional programs.

The paper presents a framework for extracting policy implications of potential relevance for India, but does not venture and propose specific policy recommendations. This is due to the enormous complexity of the task and the need to have a very detailed and systematic knowledge both of the Indian IT industry and of Indian policies. The framework comprises both the evolutionary/systems perspective to innovation/technology Policy; and the notion of policy-relevant Research. A number of suggestions for further exploration are then proposed—some arising from the Israeli case; others oriented to exploit strengths of the existing Indian software industry and of Indian capital markets. At the strategic level for example, a possible priority of policy could be “ generating large numbers of Start Up companies” as a central means for developing a product software component of Indian IT industries; and at the program portfolio level, adoption of a mix between horizontal & targeted programs oriented both to innovation/R&D more generally speaking and to Venture Capital. Additional policy possibilities oriented to existing software companies and to multinationals are also briefly mentioned.

METHODOLOGY AND WORK DONE

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

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 (Saxenian 1998). Such 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 acquired⁵. This aspect of successful company growth might be of relevant for the Indian case, and might have policy implications as well.

The importance of studying individual companies led me to focus on interviewing as many companies as would be possible within the short field visit to India during 1999. A total of 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. This was done in an intuitive way by simply choosing one company in each one of the above three groups-with the view that each category of company could make an important contribution to the future of India's software industry. The companies chosen were

- Wipro—from the group of large software services companies
- SAS---an entrepreneurial, product-software company
- Hughes Software-a foreign subsidiary.

The procedure followed contrasts with an ideal situation where a) significant knowledge about individual companies in the sector was accumulated *before* selecting the most successful ones (in the Israeli study this knowledge included categorization of all companies in the sector into three groups-very successful, moderately successful, and others including failed companies); and b) a full case study for such companies (involving more than the interview & some additional information) was conducted. For the preliminary research conducted here the selection process was much more arbitrary and the ‘case study’ work (beyond writing up the interview and checking with the interviewee) prior to selection was minimal⁶. As mentioned the cases studied are of interest not only in themselves but also as indicative of possible roles that the *three types of firms* could play in the Indian software industry.

A second point of weakness of this paper concerns an analysis of the sector/cluster as a whole. Undertaking such meso-level analysis would have gone far beyond the objectives and the possibilities available. Some ‘cluster effects’ of very successful data security companies were analyzed in the Israeli study, but even there, despite more time and resources than what was available here, the sector/cluster level of the analysis was incomplete⁷. Despite this and due to the vast amount of information readily available (from standard sources such as newspapers and the Internet) it was possible to arrive at some significant policy conclusions or at least potentially significant policy implications of the research.⁸

The final level of analysis is the *policy level*. I will try to present a relevant framework for dealing with policy issues, and this will be a systems of innovation (SI) and evolutionary framework (Teubal 2000). Needless to say, and even more than with the data security study, I will not be dealing with ‘conclusions’ but with ‘potential policy implications’ of the analysis derived from an explicit consideration of Israeli experience with high-tech in the last three decades, particularly the 1990s when that sector became one of the first non North American offshoots of the Silicon Valley ‘model’⁹.

To summarize, the report here focuses on the *firm & the policy level* with some consideration only given to potential cluster effects or spillovers from the three types of firms studied¹⁰. The work involved extensive interviewing (mostly of firms), the gathering of additional information; and elements of comparative ‘policy analysis’ which follow a systems/evolutionary perspective(see Teubal 2000). Moreover, due to inherent limitations, the firm level of analysis involved limited ‘conceptual/appreciative theorizing’.

Content of the Interviews

For independent companies the Start Up (SU) phase and subsequent phases in the growth of companies were considered. For the other companies, the interviews strived to identify the various phases in growth(e.g. climbing a quality or ‘sophistication ladder’ in terms of customized software or software services); and the major events of each phase. Particular attention was given to interactions with foreign customers and whenever relevant, ‘internationalization events’ (e.g., marketing agreements, technology transfer agreements, strategic partnerships, participation in

Standards Committees etc) took place; and links with institutions in the country, e.g., training institutes, universities, etc.

The interviews started with the origin and background of the entrepreneurs (for “independent companies”); the background conditions which led an existing conglomerate to enter software; or the creation of a foreign software subsidiary in India. In the former case it was important to understand the educational and industrial experience of the entrepreneur and his initial team; and for all companies, the initial search & learning, and decision processes which led to their first product or IT/software area.

Subsequent questions relate to the areas of activity which were added after the initial one; and the changing strategy and focus followed. Also, the links between early and later projects or activities (sequential causation and changes in the external environment coupled with changes in strategies of companies). Throughout, questions of finance and human resources were considered, as well as the impact of government policy. Project/activity impacts; and future plans and perspectives—were also considered. For the larger companies, spillovers to other firms, e.g., SU and other spin-offs, were also considered.

ISSUES EMERGING FROM THREE ‘REPRESENTATIVE’ COMPANIES

SILICON AUTOMATION SYSTEMS (now Sasken)

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)

A number of issues emerged from the interview, not all of them directly mentioned by the interviewee.

First, strong and weak aspects of the Indian software/ IT sector or system of innovation more broadly speaking-- which impinged on the firm

SAS'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. From this the company acquired experience, important links as well as representing an important source of revenues.

Second, aspects of the globalization process which favored (and could favor even more) Indian companies like SAS . 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)

Third, possible weaknesses in the software/IT cluster or system

In parallel with the undoubted academic excellence in science and engineering, there seems to be a felt need for a measure of practical orientation of at least part of the academic institutions.

There is insufficient interaction between government labs (including defense labs) and business (this is a reflection no less of future potential as it is of current weakness). The globalization of asset/capital markets has not yet affected the company –no foreign Venture Capitalist seems to have invested in the company; and no IPO was undertaken.¹¹ At this phase, large companies have enhanced possibilities of undertaking IPOs in the US whereas this is not the case yet for smaller, entrepreneurial firms. This could be linked with insufficient Venture Capital funding and an underdeveloped VC industry. There seem to be only weak links with

knowledge networks critical for innovation success, considered to be a major disadvantage of India.¹²

Fourth, Policy-Actual and Desirable Changes

A significant felt change in the attitude of the Indian government towards the software industry has been experienced during the three years prior to the interview—the government is speaking now the language of enterprises like SAS. There is lack of seed money finance, the interviewee was looking forward to some action in this area, e.g., incubators. Changes are needed in the business sector supporting structure: in generating more practically oriented graduates; in changing the governance of institutes/universities to enable and induce researchers to create/manage/own companies; and may be some link programs to promote business-university links.

Fifth, policy Issues that emerge but were not explicitly addressed are the following:

- (1) The favorable policy environment mentioned in the SAS interview relates to a targeted policy favoring software which has been implemented in India during the second half of the nineties. This includes so called ‘framework conditions’ and infrastructure (e.g. Electronic City in Bangalore). Its success is due to a number of factors—it reduces bureaucracy considerably, it is aligned in some sense with the overall liberalisation process of the country as a whole; and it is directed to a sector where the country has a clear competitive advantage in world markets.
- (2) The possibility of implementing an horizontal program supporting R&D in high-tech , including the software industry, might be considered. This has been (and continues to be to some extent) the mainstay of Israel’s strategy to develop hi-

tech industry. A grants or conditional loans scheme (with repayment only in case of R&D project sales or success). At the current stage of the Indian cluster it should be considered as complementary rather than substitute to the development of Venture Capital.

- (3) Explicit measures to promote Venture Capital, as one subsystem component of the Indian Software and IT cluster which might be aimed at (it could be a 'strategic priority'). In Israel numerous background factors explained the success of "Yozma" the government program widely credited with triggering the emergence of the Venture Capital Industry in Israel during the 1990s. One was the prior existence of high-tech industry; another was the gradual building up of links with US companies and capital market institutions.
- (4) Both background conditions exist for (and their scope is improving in) India today. Moreover, there is increasing interest of Indian entrepreneurs and engineers of Silicon Valley to participate in the Indian software sector. Thus if the Israeli example is relevant, a 'trigger' type of program or set of programs might be very helpful¹³.
- (5) A major issue is whether or not India would like to implement some 'incentives' programs or not, involving grants or conditional loans (or through an incubator program involving incentives and other support and information). Such programs might make a significant contribution but might require a very good design and non-bureaucratic implementation. Considerable thought and effort should be expended on this question; and a gradual process of implementation following "a learning perspective" could be attempted.

Conclusion: The SAS 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, e.g., such as those implemented by Israel) should continue to play a role in the evolution of Indian high-tech.

HUGHES SOFTWARE SYSTEMS¹⁴

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 was directed to the parent company.

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 (Bombay 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 which is also involved in 'product software' (an important aspect of this would seem to be the possibility of floating shares in the domestic capital market). It suggests the existence of an important mechanism in India for developing and 'reconfiguring' the existing software and IT cluster. This mechanism is not only the usual mechanism of market/management/technological spillovers and spin-offs from MNEs' which we see in Israel and probably in Ireland as well. In addition to this, it involves a process of restructuring within the MNE subsidiary itself, one leading to a mixed pattern of ownership(both foreign and domestic ownership). There are undoubtedly important policy implications from this aspect of the software development strategy of India(these might also be very specific to the Indian context).

One implication of the above restructuring is an increase in the scope and variety of 'spillovers'. 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. (It should be noted that frequently MNE subsidiaries which undertake R&D generate a lot of technological spillovers and much less market and client-related spillovers)

If future priorities of the Indian software & IT Industry involve (a) a vigorous development of software 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 accumulation of client/marketing/market-related and reputation assets could be critical for the next phase in the development of the industry¹⁵. In this context, both aspects of the restructuring of the Hughes Indian subsidiary are important—the restructuring of the portfolio of activities on the one hand; and the ‘reverse globalization’ process or Indianisation of the foreign subsidiary through its IPO in India(‘direct’ contribution of Hughes) on the other.

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. Thus the ‘Hughes way’ could become an important spillover of MNE at this phase of their development.

Conclusion

The Hughes case and the above-mentioned Israeli study suggest 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 facilitates a small subset of very good companies to undertake IPO in NASDAQ (and now increasingly in Europe) rather than to be acquired very early by a foreign multinational; and (2) the Hughes example which suggests that pre-existent MNE which populated the first phase in the development of the Indian software industry may eventually become or increasingly behave like an Indian company while simultaneously shifting to some

extent to 'product software' areas. I suggest that both mechanisms should be explored. 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 SAS case above and the inferred policy implications).¹⁶

WIPRO INFOTECH¹⁷

The company is part of a large conglomerate one of the largest in India, and is one of India's largest software companies. It made a decision to enter the IT area in 1980, due to restrictions on imports of minicomputers. At that time only 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(A Canadian Multinational), GE, etc. Later on, it started to offer integrated software/hardware design services. Some product development activity has also been undertaken, but this represents 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 Activity

The next phase would seem to 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 are system integration and solutions development and operations support activities of a higher level of sophistication compared to the past. However, the company seemed to have no plans (till September 1999) 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. The case also suggests (given Wipro's ownership of a Silicon Valley company and a one- shot transfer of technology to another company there) that the large Indian software companies could promote the development of SU in the IT and software areas , and even of Venture Capital.

Mechanisms by which large Services Software companies may stimulate product software SU companies include: (1) Undertaking product-software development activity with eventual spinning off of 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 companies. This mechanism might be considered as one of the central mechanisms through which the Government of India might want to promote SU formation; (3) investment in Indian SU companies; (4) creation of or investments in VC funds; (5) agreements or partnerships with SU companies

Implementing the above involves important strategic and organisational 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)

ISRAEL’S HIGH-TECH CLUSTER OF THE 1990s-BACKGROUND, EMERGENCE AND POLICY PROFILE

During the 1990s the Israeli economy continued the process of structural change initiated in the seventies (Teubal 1993) but in an accelerated mode (Justman 2000). 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 that of all OECD countries (Avnimelech et al 2000, Table 1.1). High-tech exports quadrupled from 1991 to 1999—from a level of \$1700 million to \$6600 million; and the share of high-tech exports in total manufacturing exports, which has grown steadily throughout the last three decades, 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.

But not less important than the quantitative aspects 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. The changes include 1) large numbers of SU companies; 2) significant Venture Capital investments; 3) strong links with the US (Silicon Valley, Wall Street, etc). These are elements of what can be termed the “Silicon Valley Model” of high-tech (Saxenian 1998).

Background and Main Features of the New High-tech Cluster

Israel's Successful Adaptation to the New Globalization Wave

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 decades of the millenium and of 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 the factors-

- 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; 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 into hi-tech sectors), e.g., Sweden and other Scandinavian countries, Taiwan, India, Korea, etc. 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.

In what follows I will briefly analyze capital market links and direct foreign investment; and then proceed to give some information on Start Ups and on Venture Capital.

Capital Market Links with the US and Integration with the US Economy

The proximate causes mentioned above co-evolved with the evolution of the high-tech cluster during the last decade. A *central feature* distinguishing the Israeli hi-tech cluster from Europe’s and from Israel’s a decade ago is the extent of integration of Israeli hi-tech with US asset and capital markets. 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 (this may change in favor of Europe or Japan with 3G mobile technologies). 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)¹⁸. 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.¹⁹ 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. The table below gives information on public offerings of Israeli companies in the US between 1993-97 period.

Table 1

CAPITAL RAISED IN PUBLIC OFFERINGS OF ISRAELI COMPANIES IN THE US(1993-1997)

Year	Number of Offerings	Capital Raised (\$million)
1993	17	529
1994	10	336
1995	16	608
1996	31	982
1997	22	743
Total 1993-97	96	3,198

Foreign Investment in Israel

A word of caution: there are partially unsolved conceptual (e.g., and adequate typology) and measurement issues as well as data lacunae. A major distinction in the data is between foreign investments in unlisted companies and foreign investments in listed companies.

Table 2

FOREIGN INVESTMENT IN ISRAEL—billions of dollars

	1997	1998	1999	2000
Direct Investment by Foreign Residents		1.8	2.9	5.0
Investments in listed securities investment portfolios		2.5	2.7	5.0
Other(e.g deposits by foreign residents		0.1	3.4	1.4
Total	8.1	4.4	9.0	11.4

Source: Bank of Israel Report, January 31st 2001.

The \$11.4 billion figure for the year 2000 is significant in terms of GDP. It reflects important increases over previous years; and it will represent a peak for some years to come. Out of that figure, \$4.2 billion (approximately) were foreign investments in *publicly traded securities*-- especially Israeli companies floated in Wall Street (but also in Tel Aviv's Stock Exchange); and the rest were foreign investments in *private companies*—mostly purchases of Israeli Start Ups (about \$7.2 billion—*Haaretz* 1-02-2001)¹. Foreign investments in private companies are implemented through transfers of cash, through equity swaps; or through a combination of the two²⁰.

Importance of SU companies

The high-tech cluster of the 1990s becomes much more 'intensive' in Start UP firms (SU) and in Venture Capital companies (VC) (Teubal 1999); and it is much more integrated and linked with the US and its hi-tech clusters in Silicon Valley and elsewhere. Concerning the former we have the following information for the year 1999 (Source: Office of the Chief Scientist (OCS): a) about 2500 Israeli Start Up

companies operated in 1998; b) about 1000 such companies were created in 1999 alone; and c) some 300 Start Up companies are processed by the OCS each year (200 apply directly to the 'regular R&D' promotion scheme; and the rest –till 1998- via the Technological Incubator Program).

Venture Capital—Quantitative Figures

A number of indicators could be thought of. We start with: a) capital raised by different types of VCs till the end of 1997, and b) the share of that which was actually invested.

Table 3

NUMBER OF VC-FUNDS, CAPITAL RAISED(\$ M, TOTAL & PER YEAR);AND CAPITAL INVESTED(\$ M, TOTAL & SHARE OF CAPITAL RAISED)-TILL December 1997²¹

<i>Type of Fund</i>	No. Existing Funds	Total Capital Raised	Capital Raised 1991; '92	Capital Raised '93-'94	Capital Raised '95-'96	Capital Raised 1997
Yozma Funds	10	229(87%)	0; 0	149; 40	15; 20	5
Private Funds	37	1117(39)	49; 29	49; 86	64; 267	573
Public and "Other"	7	119(77%)	9; 88	22; 0	0; 0	0
TOTAL	54	1463(50)	58; 117	220; 126	79; 287	578
Other Private Equity Funds	27	621(75%)	0; 45	128; 242	91; 115	0
ALL FUNDS — TOTAL RAISED	81	2086(57)	58; 162	348; 368	179; 402	578
ALL FUNDS-						

¹ Haaretz is an Israeli Newspaper

TOTAL INVEST ED		1,189				

The first three types of funds—Yozma, Private, and Public & ‘Other’—are pure *technology-oriented funds*, while the category ‘Other Private Equity Funds’ include funds that invest both in high-tech and in non-high-tech. The total sums raised till the end of 1997 was \$1,189 million. ‘Yozma Funds’ are private funds which benefited from government incentives (see next subsection). These predominated in 1994 –the year when the first five (out of 10) such funds were created. ‘Other Private Equity Funds’ predominated in the other years excepting 1996 when ‘Private Funds’(ie. technology-oriented, non-Yozma funds) were the dominant category. We will see that Yozma funds are widely believed to have triggered a dynamic process inducing, among other things, industry entry by other private funds (both funds specialized in high-tech –the second category in the above table; and funds which are not). Thus the total contribution of Yozma Funds would be significantly higher than their direct contribution²².

Capital Raised during 1998-2000

After 1997 the amounts raised by VCs increased considerably. Avnimelech & Teubal (2001) reports that capital raised by VC funds in 1998 amounted to 688 \$ million and 1617 \$ million in 1999(the latter confirmed by data from research company Zinuk).

Reports from the press tell that twentyfour Venture Capital Funds raised \$3.2 billion during April-October 2000 ²³. This is about double the capital raised during 1999.

Accumulated Sums Raised/Managed

In our interview with Giza (late 2000) it was stated that the sums raised during 2000 approached \$4 billion; and the total amounts under management was \$5 billion. This order of magnitude is confirmed by the *Haaretz* article: it mentions that the thirty-two Venture Capital funds interviewed manage a total of \$5.28 billion. It also mentions that that the accumulated stock of funds raised by the Israeli VC industry is expected to reach the sum of around \$7.5 billion about half of which has been actually invested. This leaves an enormous amount to be invested in 2001 and beyond.

It should be noted however that the vast increase in capital raised by VCs in Israel in the last year or two 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.

Dynamics of the Emergence of VC in Israel²

Numerous background factors, specific Government initiatives, and complementary events are necessary to explain the emergence of the VC industry in Israel in the early 1990s (Gelvan and Teubal 1997). Background conditions included the prior existence of a civilian hi-tech industry, the prior existence of an horizontal program supporting ('regular') R&D in the business sector (see below); liberalization of capital markets during the 1980s, and of the economy more generally speaking; a

² See also Avnimelech & Teubal 2001

successful price stabilization program; and the restructuring of military industries (also during the mid-1980s).

Here we will focus here exclusively on the ‘trigger’ effect or process which followed a particular government program-Yozma-which, as I mentioned, is reputed to have triggered the process of emergence of Israel’s VC industry. The program began operating in 1992. It was based on a \$100 million fund (with the same name) oriented to two functions: a) investment in private VC funds(‘Yozma Funds’-\$80 million); and b) direct investments in high-tech companies-\$20 million. The basic idea was to promote the establishment of Israeli VC funds with the support of government and with the involvement of foreign financial/investment institutions. Each fund would have to involve one such foreign institution & a well-established Israeli financial institution. The object of the funds would be to invest in young Israeli high-tech start ups. When a fund fulfilled these conditions, the Government would invest (through Yozma) around 30-40%(up to \$8 million) of the funds raised. Each fund also had a call option on government shares, at cost (plus interest) and for a period of five years. The explicit objective was to create a solid base for the industry; to learn the business from foreign partners; and to possess a network of international contacts. The Government was willing to grant a bonus or premium to foreign institutions willing to invest in Israeli VCs despite their lack of experience.

In total ten ‘Yozma funds’ were created-five in 1993; two in 1994; two in 1995; and one 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

Venture Capital co-evolved with Start Ups 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 today is approximately \$5 billion, a large share of total funds managed today.

Phases in the Evolution of Venture Capital³

We can distinguish between three distinct phases in the evolution of Israel’s VC industry: Phase 1 (1993-96) during which the *direct* impact of the government’s Yozma (and to a lesser extent Inbal) Programs took place; Phase 2(1996-99); and Phase 3(1999-)where Israeli VC funds are establishing offices abroad and investing more and more in non-Israeli hi-tech companies.

Phase 1(1993-96)

We mentioned that during the first years ten Yozma funds were created (i.e. funds which received incentives from the then created government owned VC company-Yozma); and another four under the influence of the Inbal program. Yozma was a partner in Yozma Funds (usually with a stake of 40%) and also provided incentives in the upside (an option to the non-Yozma 60% to purchase Yosma’s share at cost); while Inbal provided incentives in the downside(Government insurance). They were sponsored by important domestic financial institutions as well as by foreign

³ See Avnimelech & Teubal 2001

investment institutions such as Advent, Walden and TVM. VC fund size was small—about \$20 million; did not have experience and invested largely on the basis of intuition with relatively little knowledge about specific segments/areas of industry; and they invariably co-invested with other funds(in order to spread risks). Embedded in Yozma’s policy was the requirement that there be sponsorship by a foreign organization since the funds created did not yet know what was ‘Venture Capital’. The foreign organizations helped manage the funds and promoted a learning process. Israeli VCs learned how to undertake VC transactions, how to undertake ‘due diligence’, knowledge of the market, etc. Funds without foreign partners learned from those with foreign partners through co-investment (Collective Learning). During this process, Start Up companies themselves also learned how to work with VCs and what VCs could offer them in addition to finance.

The objectives of funds in the first phase was to exit through M&A, i.e., through sale of the Israeli Start Ups to a (usually foreign) large company. Large numbers of such transactions took place at low values (between \$10-70 million). This is the easiest way of “exiting” and therefore the standard one adopted during this period.

Phase 2(1996-98)

During the second phase a larger number of corporate strategic partners began to participate in the funds, as well as institutional investors such as pension funds. Most of the effort was devoted to develop links with investment banks (and with the most important analysts in US investment banks) since the objective was to ‘exit’ through IPO rather than through M&A. During this period, VC funds were larger (around \$100 million) with a large component of important international

organizations. VC fund managers became more experienced and they better understood the business. They succeeded in generating ‘value added’ over and beyond the equity they purchased; and they realized that it was not enough to identify good companies. They also spent more time with each individual portfolio company. They discovered that there could be problems with Start Up managers so they devoted more time to build up the management team of portfolio companies. Finally, they realized that selling a company is not the wisest move, that the challenge is to help companies grow. This means that they increasingly had to relate to the market. During this period we also see a process of generating links with US Venture Capital companies. This would enable to utilize their strategic links with companies and other organizations. At this stage we see the beginnings of investments not only in Israeli Start Ups but also in Israeli-related companies, e.g., US companies founded by Israelis.

Phase 3(1999-2000)

In this phase VC funds were larger—over \$200 million; more partners in particular US partners; establishing offices abroad (today all leading VCs have offices in the US, in Europe or in both). There is an increased emphasis in linking directly with strategic partners like Nortel, Cisco, AOL, Yahoo, etc., and continued and enhanced efforts at understanding the market. Correspondingly, there are less links with investment banks (also by then investment banks by themselves would offer their underwriting services to good Israeli companies). This reflects the fact the Israeli companies by then already acquired an international reputation. In those circumstances any inquiry of an Israeli VC concerning IPO of one of its portfolio companies would lead the investment bank to check the company. In this phase, competition is global competition, and good Israeli companies know how to ‘reach’ or

‘access’ US VCs alone; and the latter also directly search for good companies in Israel. US VCs have an advantage that they know better than Israeli VCs how to search for good managers in the US. They also have better links with strategic partners; and better knowledge of the market. Israeli VCs try to link directly to strategic partners (and not through US VC) who frequently are also investors in their funds. We can say that the objective here is not only to exit (including the option of doing so through an IPO as in the previous phase) but also of building large, indigenous companies which means also post-IPO activity.

Policy and its Impact (1969-2000)

General

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 whose objective is the creation of 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. 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.

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 1996/7²⁴.

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.

They have been two distinct phases in Israel’s R&D Strategy and we are (or have been for a couple of years or so) at the onset of a third one. These largely correspond to the evolving high-tech cluster of that country. 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 (1990-98); and to the current and expected re-configuration of such a cluster (1998--). We will refer to the first two.

Phase 1(1969-1990): A horizontal program supporting ‘regular’ R&D

A framework for understanding the impact of the Industrial R&D Fund is to adopt an evolutionary perspective to the implementation of the program. The objective of the program would then be *penetration and diffusion of ‘regular R&D’ throughout the business sector.*²⁵ 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 are non-existent or only existent in small ‘islands’ within the business sector. Therefore *the major objective—during the infant phase of implementation- is to promote learning about R&D/innovation*²⁶. 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. The first box below proposes a certain categorization of intra-firm learning processes); while the second box, some specific aspects of ‘collective learning’ during 1969-90 in Israel²⁷.

Figure 1

<i>INTRAFIRM 'LEARNING ABOUT R&D/INNOVATION'-Infant Phase of an HTP</i>
1. Learning how to search for Market and Technological Information
2. Learning to identify and generate new projects, including more complex ones
3. Learning to screen, evaluate and choose new projects
4. Learn to manage the innovation process(linking Design to Production & Marketing;

Selection of Personnel; Budgeting; etc); etc
--

Figure 2

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

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

Mature Phase of HTP implementation—From Promoting Learning to Policy Restructuring

The evolutionary perspective to HTP states that after the infant phase of implementation of such a program (say 5-10 years depending on context) a number of developments will very likely take place: exhaustion of learning opportunities and associated externalities (in certain areas); new opportunities for complex types of R&D projects (based on capabilities generated in simpler projects); and identification of possible areas of competitive advantage. The policy implications ideally would involve a) within the HTP program—likely reductions in average R&D subsidies together with greater selectivity; b) beyond the HTP program—the implementation of a number of additional programs, e.g., targeted programs for specific areas/technologies; and targeted/horizontal programs supporting generic, cooperative R&D; etc.

In Israel only a very limited adaptation did occur during the first phase, i.e., till 1990. The box below summarizes the situation

Figure 3

Israel: Policy Restructuring (1969-1990)
1. A new scheme for supporting large, complex projects involving a University Research component (“National Projects”) was initiated in the late 1970s and continued till the early 1980s. This scheme provide up to 80 % subsidy of R&D rather than the usual 50%(it was not targeted to specific technological areas/industrial branches)
2. A new targeted program supporting ‘regular’ R&D cooperation between a US and an Israeli company was established—BIRD ⁴ (in 1977). Despite modest disbursements, BIRD has been widely held as having contributed in an important way to the generation during the 1990s of Israel’s wide-ranging high-tech links with the US
3. A more significant restructuring of ‘the R&D Industrial Fund’ took place only in the second half of the 1990s, when budget cuts were implemented and when Venture Capital partially substituted for OCS R&D support.

BIRD must have been implemented as a result both of enhanced ‘globalization’ which created new opportunities; and of endogenous forces linked to the implementation of the ‘the Industrial R&D Fund’, particularly, the realization that

⁴ Binational Industrial Research & Development Fund.

a potential existed for ‘regular’ R&D collaboration between US and Israeli companies.²⁸

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 op. cit., Toren 1990; and Michlol 1999, Justman and Zuscovitch 1999).

Phase 2(1990-1998/2000): Expansion and Diversification

Successful implementation of the core or backbone program, *through an evolutionary/ dynamic process*, has led to the emergence and implementation of a set of other programs in the early 1990s(see Program Sequencing Box below). Simultaneously with this, we see an expansion of the ‘regular’ R&D support program till 1997. See data in Table 4 and the summary of OCS activity for the year 1997

Figure 4

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) <i>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.</i>
2) <i>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.</i>

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 early years.

TABLE 4: OCS R&D GRANTS (NOMINAL \$ MILLION)

Year	Grants	Percent Change over Previous Year
1989	125.3	4.3
1990	136	8.6
1991	178.6	30.8
1992	199	11.7
1993	231	16
1994	316	36.7
1995	346	9.4
1996	348	0.5
1997	330	-5.4
1998	254	-23

Source: Israel Ministry of Industry and Trade, Office of the Chief Scientist (OCS), "Encouragement of Industrial R&D in Israel", Jerusalem, September 1999

Table 5: Summary of Activities of the Office of the Chief Scientist (OCS) in 1997

Number of Firms requesting support	623
Number of Project Support Requests-submitted	1311
Number of Project Support Requests-	1007

approved	
Grants Approved	\$ 397 million
Royalties paid by companies	\$ 103 million
Number of projects underway in 26 Technological Incubators	212

Source: Slide presentation of Chief Scientist, Dr. Orna Berry, 1999.

Program Sequencing and Policy Learning

Underlying the spate of new programs of the early 1990s--an expression of significant policy restructuring and diversification beyond the original backbone HTP program—is a significant process of ‘policy learning’, both experience-based learning and research/search-induced Knowledge Acquisition by Policy makers. These enabled Israeli policy makers (particularly the OCS) to ‘adapt’ to the changing external and internal circumstances. Among the former we have: 1) the success in creating a well identified civilian R&D performing and high-tech sector during the 1980s; 2) the restructuring of the military industries during 1984-87 including cancellation of the Lavi fighter plane project and other reductions in military R&D which led large numbers of skilled personnel to enter civilian industry, e.g., absorption by incumbent hi-tech companies or through the creation of a wave of new Start Up companies; 3) the high rate of failure of the such Start Ups²⁹; and 4) the widespread diffusion of ‘regular’ R&D/ Innovation Capabilities throughout the Business Sector, and the possibilities this offered to enter new forms of cooperative, pre-competitive/generic R&D. Changes in the external circumstances included: 1) the breakdown of the former Soviet Union which brought a very large number of immigrant scientists and engineers to Israel; 2) greater legitimacy acquired by Israel after the Gulf War and greater disposition of foreign nations to be linked with her; 3) further deepening of the globalization process in particular new opportunities to be

linked with US asset and capital markets (e.g., large US investment banks and private equity investment companies began searching for investment opportunities in Israel);

4) the implementation in Japan, Europe and the US of government programs supporting cooperative, generic R&D.

The ‘dynamic effects’ underlying the above mentioned diversification of policy/country adaptation to changed circumstances include—

1) Policy learning underlying Yozma: 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. Venture Capital is a very special financial institution much more linked to high-tech industry than to traditional financial institutions; and much more adapted to the new global economy since it provided Start Ups vital information, knowledge and links with clients, strategic partners and world asset/capital markets. Venture Capital involves at least three components: equity (rather than extension of loans, value added (help in defining a strategy and business model, marketing-management-headhunting roles; opening doors to clients and strategic partners; and links with world financial institutions). As a result of this search process, the then Chief Scientist (Ygal Erlich) implemented a number of alternative programs oriented to generate a domestic Venture Capital Industry. These included *Inbal*— a program of government guarantees to investors in Venture Capital funds; and the more successful *Yozma* –a government owned Venture Capital company.

2) ‘Policy learning’ and the Magnet Program: Planning and Research which led to this program was systematically undertaken by the Industrial Development Policy Group (IDPG) of the Jerusalem Institute for Israel Studies, in 1989—two years before

actual implementation. The initiative came from academia, not from the OCS. The research painted a convincing picture of ‘market failure’ in the new technological activity—cooperative/generic R&D; and the outcome was implementation of Magnet in 1991/2. This program is considered to be very successful and to have contributed to the generation of a new R&D culture in Israel (one which enables the co-existence of competition with generic R&D cooperation).

The third program—the Technological Incubators Program—was implemented as a direct response to the wave of scientists/engineers coming from the former Soviet Union. While originally oriented to this group it rapidly became an option for any Start Up –that is such a company could either apply to the ‘regular ‘ R&D Industrial R&D Fund or to the Technological Incubators Program.

Economic Impact of the new Policies

No doubt that the restructured ‘program portfolio’ of Israel had a very important impact on the growth of high-tech during the 1990s and in particular to the emergence of the new ‘Silicon Valley’/VC and SU-intensive cluster. This assertion is based on the ‘microeconomic insights’ of entrepreneurs and policy makers; on the fact that there has been enormous growth of high-tech during the last decade; and to ‘collective knowledge’ about the role of Venture Capital in the whole process. This belief, however, has not yet been buttressed by systematic program evaluations or econometric analysis.³⁰

POTENTIAL POLICY IMPLICATIONS: A COMPARATIVE PERSPECTIVE

My objective is to extract some potential policy implications; more specifically, how could the Israeli experience suggest possible lines of action in the policy field?

It is important to notice that India has implemented successfully during the 1990s a coordinated set of policies targeted to the software industry—which despite its targeted nature is consistent with the overall liberalisation trend within the Indian economy. There is no doubt that the country—partly as a result of such a policy—presently enjoys a comparative advantage in software and in IT more generally speaking. This follows from some of the factors mentioned above: high quality graduates, low costs of skilled labor, the market share and reputation achieved especially by the large software companies (which overwhelmingly are involved in software services and in customized software applications); the reputation that the industry as a whole has achieved in world markets; good and growing personal linkages with Indians working in Silicon Valley and elsewhere; the apparent disposition of increasing numbers of such Indians and of Venture Capitalists to come to India to search for and invest in projects.

Second, the existing IT/Software industry might represent a spring board for the emergence of a product software/IT segment. There are several tens or more of such companies who are entrepreneurial; and who like SAS(Sasken) could immediately benefit from Venture Capital and from policies designed to promote a ‘Silicon Valley’ type segment adapted to Indian circumstances. Moreover both existing Multinational Corporations (like Hughes Software Systems) active in India on the one hand; and large Software companies (like Wipro Infotech) on the other could—directly and indirectly-- play important roles in the emergence of such a segment. The benefits could take the form of spin-off companies involved in the new areas; technological,

market/ marketing & managerial ‘spillovers’; networking & reputation effects; and actual investments in new ventures.

In discussing potential policy implications I will be making use of the ‘Systems and Evolutionary Perspective to Innovation and Technology Policy’ (Teubal 2000 and other researchers cited there). Under the above perspective a fundamental distinction is 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(policies)*. Policies could be oriented- directly to the business sector(like Israel’s backbone horizontal program supporting ‘regular’ R&D), to the supporting structure(like Israel’s Magnet and Yozma programs); to enhance interactions(e.g. university-company interactions) and links-- including external links of the system(like Israel’s BIRD program), or to culture and social Structure. The discussion ignores the various levels of policy relevant to India(national, state and local).

Elements of a Possible Vision/Strategy and Priorities

The Israeli experience in promoting IT and also product software through a set of specific programs suggest that development of India’s IT industry could benefit from a policy induced, process of incorporation of some characteristics of the Silicon Valley model of high-tech. Continuation of the globalization process which is diffusing such a model worldwide would seem to be an opportunity for India given the factors mentioned above and its existing successes in the software services area.

The *vision* could include the following two elements

- continued growth of large companies and SMEs in the software services + customized software areas
- emergence and development of a thriving, competitive product software segment, and of R&D-based IT, more generally speaking.

The *strategy* should involve the following

- creation of large numbers of SU companies in product software areas—hundreds or thousands every year.
- effective transition from R&D/SU phase to post R&D/SU phase; and emergence of a subset of high-growth SU companies(‘gazelles’)
- emergence of a set of large domestic companies in the software products area which have acquired world status.
- creation of a domestic Venture Capital industry with characteristics similar to those of the US and Israel (the VC industry operating/located in India will eventually include foreign VCs also)
- enhanced links with global capital and asset markets including NASDAQ.

The above elements of strategy were, more or less explicitly, those underlying Israel’s new set of policies during the 1990s. In India, the strategy for creating SU would explicitly consider the potential contribution of existing, especially large, software services companies; as well as other sources (e.g. university graduates, spin-offs from government labs/universities, spin-offs from MNEs, Indians returning from abroad, etc). In Israel, the existing civilian high-tech sector which emerged in

the 1980s during the first phase (1969-1990), together with other factors, played such a role.

Before venturing to translate the above into policy terms it is important to realize that successful SU formation might involve *co-evolutionary processes* such as that existing between SU companies and VC companies³¹. In Israel the capabilities of the VCs would determine to some extent the profiles of growth of very good SU e.g. a ‘fast IPO’ or a ‘fast M&A’ track. Trying to trigger a co-evolutionary process is much more difficult than to influence a set of unlinked variables one at a time. Israeli success was facilitated by very favorable background conditions for creation of SU. These seemed to have led to a situation of ‘excess demand’ for VC-services in the late 1980s, early 1990s. when Yozma was implemented (thus the need was a concrete, felt need). Such conditions included certain features of pre-existing high-tech (which also exist in India today) and of pre-existing policy (the backbone program supporting R&D horizontally and neutrally). In that context a well designed ‘targeted’ program supporting Venture Capital would had a good chance of succeeding.

The upshot for the Indian case is that simply stimulating VC may not succeed if SU companies are not there in abundance. If this is the case, explicit policies stimulating start-ups might have to precede or might have to be implemented in parallel to policies promoting VCs. This means coordination of a wide range of policies, both incentives’ programs and institutional changes.

FINAL OBSERVATIONS

This paper embodies a particular view, including a methodological perspective, of *policy relevant research*. In cutting-edge topics involving very dynamic phenomena such as India’s policy for the promotion of IT industries it may

be necessary to adopt a multidisciplinary and multi-methodological approach rather than directly jump to measurement and econometrics first, and from there to policy conclusions. In the case of the emerging ‘Silicon Valley model’ of high-tech it is important to consider several levels of analysis—a firm level (where case studies play a role); a cluster level of analysis (like Saxenian’s work on the above model of high-tech, where ‘conceptual theory’ is critical); and a policy level of analysis. The latter could then benefit from econometric work but only after the specific formulations adopted are influenced by prior firm & cluster analyses. Policy analysis also must consider the policy process and the country specific ‘policy framework’(see Teubal 2000 op. cit); and it may be imperative adopt a comparative perspective. I suggest thinking in ‘strategic terms’ following a systems and evolutionary perspective to innovation and technology policy; and I emphasize the continued importance of policy-relevant research.

Comparative analysis could be crucial at the policy analysis stage, and this is represented in the paper by an explicit consideration of the Israeli case. Despite the enormous differences among the two countries, it seems to me—given that Israel is one of the first non-North American offshoots of the new model of high-tech-- that some aspects of Israeli policy could be explored further and considered as possible options in the Indian context. Among these I would include the strategic objective of facilitating a shift to product software, of stimulating large numbers of Start Up companies; of stimulating Venture Capital; of considering a mix both between horizontal and targeted programs and between policies directed to the business sector and those directed to the supporting structure; etc

ENDNOTES

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² See Teubal 1999, Bartzokas & Teubal forthcoming, Teubal, Avnimelech and Gayego 2000; and Avnimelech, Gayego, Teubal and 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 1996 for a recent description of evolutionary theory as applied to the study of economic and social change.

⁴ See Teubal & Avnimelech 2001. 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.

⁵ Among the potential differential effects favouring indigenous companies over good companies who were acquired by foreign multinationals we found the accumulation of a wider and more balanced set of intangible assets (including those which are client and marketing related assets, which frequently ceases when such companies are acquired by foreign multinationals); the help that large global indigenous companies provide to smaller hi-tech start ups through partnerships, investments, contributions to ‘scaling up’ (taking a company from \$5 Million sales to \$50 Million), and OEM (Marketing) Agreements. In the Israeli case many good companies being acquired by large foreign multinational companies focus on R&D and technology rather than on ‘Innovation’ more generally speaking. The point here is not a ‘nationalistic’ point but a recognition that the forces of Globalization create differential impacts of different companies in different national contexts. Moreover, the statement made above about seeming advantages of having a higher share of very good companies that remain indigenous than the share resulting from ‘market processes’ depends very much on the particular IT segment being considered; on the phase of development of the relevant high-tech cluster, and on the features of the post acquisition phase of acquired companies.

⁶ This in part explains why the report here is preliminary or tentative. In addition, the Israeli study also identified the ‘growth profiles’ of the successful companies. This is

an exercise in conceptual or appreciative Theory which goes beyond the ‘case study’ itself.

⁷ One of the reasons for weakness in the analysis at the cluster level is that the relevant cluster goes beyond the data security segment . It must involve e.g. hi-tech communications equipment companies as well. At the rate at which the research has been performed there, at least two additional years are required e.g. to analyze the hi-tech communications equipment segment; and Venture Capital.

⁸ One major conclusion was that undertaking an Initial Public Offering (IPO) is a necessary condition for very successful data security companies to internationalize while remaining indigenous, at least for a time. Thus if a strategic priority of innovation/technology policy is achieving ‘R&D leverage’ in terms of value added and employment growth no less than promoting R&D itself; and if this in turn involves enhancing the share of very good companies which remain indigenous---then policy might have to be geared to enhance the potential of very good SU companies to undertake a ‘fast IPO strategy’ rather than a ‘fast M&A strategy’.

⁹ For a characterization of the Silicon Valley model of high-tech (cluster) organization see Saxenian 1998.

¹⁰ A full meso-level of analysis requires not only a study of spillovers and other indirect contributions from very successful, Key companies but also a study of the business sector supporting structure e.g. universities , links and interactions within the

hi-tech cluster and between it and agents abroad; and institutions and culture/social Structure. See Teubal & Andersen 2000, Teubal 2000 op. Cit

¹¹ 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).

¹² 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.

¹³ In general such a program or set of program would involve a mix between “incentives” and institutional changes. It must also consider the demand, supply and learning aspects. See Teubal 2000 sections 2 and 3 which deal “emergence/stimulation of demand”.

¹⁴ Data as of late 1999.

¹⁵ 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.

¹⁶ Note that there is a third mechanism for shifting to an enhanced ‘product-software’ intensive cluster(which also includes and indigenous company component) which is through the evolution or contribution of large indigenous software “services” companies.

¹⁷ Data upto September 1999.

¹⁸ See Blass and Yafe 1998. To date 97 Israeli companies are traded in the US of which 47 have a MarCap of \$500 million or more (*Haaretz*, August 7, 2000).

¹⁹ 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).

²⁰ The information about this and about the other major component of Foreign Investment published in the *Haaretz* newspaper only roughly (rather than precisely) corresponds to the Bank of Israel figures of the table. This is not detrimental though for our purposes here.

²¹ Data published from Israel Venture Capital Association (IVA). There seem to be problems with VC-type data, starting with the definition and typology of Venture Capital. A different definition and typology would lead to different figures.

²² Avnimelech & Teubal 2001 report that the ten Yozma funds(those directly benefiting from the incentives and other policies of *Yozma*—the Government owned

VC fund created in 1992) –including twenty ‘Continuation Funds’--have a total of \$5,100 million under management. They also invested in a total of 415 portfolio companies.

²³ Survey by the newspaper *Haaretz* of thirty-two VC funds, reported on October 24, 2000. The same newspaper article mentions that other funds are in the process of raising another \$2.45 billion.

²⁴ 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.

²⁵ Initial conditions in the ideal HTP model, which to my mind reflects 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).

²⁶ 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.

²⁷ 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).

²⁸ Numerous reasons may explain the relative absence of policy restructuring during the 80s, but a major one was the macroeconomic instability of the country, which together with other factors, seriously affected hi-tech industry. OCS's support seems to have generated some stability; it also played a role in generating employment opportunities for engineers/scientists who were reshuffled from the military R&D establishment.

²⁹ Personal communication, Ygal Erlich(former Chief Scientist), 1998

³⁰ For a systematic review of some the econometric issues and of existing econometric work see Trajtenberg 2000. That paper also discusses some operational policy issues connected with OCS budget cuts (which began in 1970). This contrasts with the analysis of Teubal 1999 and with current work which focuses on "strategic" rather than on 'operational' issues. By identifying the central elements of Israel's R&D Strategy such work paves the way for 'comparative' analysis of innovation/technology Policy.

³¹ 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.

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