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**CREATING VENTURE CAPITAL (VC) INDUSTRIES THAT CO-EVOLVE
WITH HIGH TECH: INSIGHTS FROM AN EXTENDED INDUSTRY LIFE
CYCLE (ILC) PERSPECTIVE OF THE ISRAELI EXPERIENCE***

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Abstract

This paper presents an extended Industry Life Cycle model of Venture Capital (VC) and associated Startup-Intensive or 'Entrepreneurial' High Tech clusters based on the Israeli experience of the last 35 years. Throughout Venture Capital is considered a new industry and/or market, which when successful traverses five distinct phases: Background Conditions, Pre-Emergence, VC Emergence, Restructuring and Consolidation. Each phase comprises a number of events and processes, including policy ones, linked through or associated with evolutionary Variation, Selection and Development. A central process is VC emergence—a cumulative, autocatalytic process involving a number of phased, interrelated sub-processes operating through time. A central sub-process in the Israeli case was VC-startup co-evolution, which was the critical link between the VC emergence in that country and the transformation of its high tech cluster into an entrepreneurial, Silicon Valley configuration.

An important focus of the model concerns triggering and sustaining the process of VC emergence. Linked to this process our analysis suggests that, provided appropriate Background and Pre-emergence conditions prevail or are created by policy, VC could be a driver or central vector in the transformation of existing high tech clusters (towards a more 'entrepreneurial' mode) or in the creation of new clusters. This would not be an automatic process and may require, like in the Israeli case, appropriate policies e.g. targeting VC. Therefore, under certain conditions, VC could become a major mechanism by which a country or region could latch into and benefit from the ICT (Information and Communications Technologies) Revolution. Our analysis also suggests that absence of a VC industry with strong co-evolutionary effects with startups may be a significant factor in the *non-emergence* or limited diffusion of the Silicon Valley 'model' of high tech clusters beyond the U.S. up to and including the 1990s.

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Key Words:

Venture Capital, Startups, Industry Life Cycle, High Tech Cluster, Emergence and Evolutionary Economics.

1. Introduction

Venture Capital (VC) consists of “independently managed dedicated pools of capital that focus on equity or equity-linked investments in privately held, high growth companies” (Gompers & Lerner 1999, p. 349). As far as the organizations involved in venture capital are concerned this definition allows for two variants, a narrow one and a broad one. The *narrow* or *strict definition of VC companies* includes those organizations with a ‘dominant’ orientation to the *early stage* finance of **high tech Startup companies (SU)**. Startups are defined here as young, high tech companies whose main activity is R&D up to initial sales stage (usually between 1-5 years old). This is the dominant category for characterizing Israel’s VC *industry* (see table 2). The broad definition of VC organizations also comprises organizations which in a dominant way invest in privately held, high growth companies but these need not be high tech nor focus on the early phase of such companies. Thus, they would also include organizations dominantly oriented to investments in the mature phase of startup companies (usually between 5-10 years old, as long as they are still privately held). This is the definition used in the available statistics of most countries, including Israel (see Box 1). **Private Equity (PE)** organizations represent an even broader notion which focuses on private equity investments both in high growth companies and on mature, privately held or publicly traded, companies. It follows that the set of PE organizations includes the set of VC organizations and other PE organization that focus on non high tech companies and/or on late stage investments in companies undergoing restructuring e.g. Management Buyout/in (MBO/MBI).

While the first U.S. VC company was created in 1946 (American Research and Development Corporation, see Bylinsky 1976) a significant VC *industry* and *market* emerged in the U.S. during the mid 1970s (Avnimelech et al., 2005; Gompers, 1994; Gompers & Lerner, 1999) in the wake of the ICT and integrated circuit Revolution and the creation of NASDAQ in 1971. Its diffusion to Israel during the 1990s took place in the context of Globalization of the main Capital Market focusing on IPOs of young technology companies–NASDAQ (which was the main channel for Israeli VC exits). When strictly defined, Israel’s VC industry during the 1990s became one of the largest VC industries in *absolute terms* (only second to the U.S.) and the largest in *relative terms* (VC as percentage of GNP). Box 1 presents the distinctive features of Israeli VC.

Box 1: Distinctive Features of Israel's VC Industry (during the 1990s)

<i>Highest VC investments as a share of GNP</i> (see OECD 2004) – 0.7% during 1999-2002, compared with 0.48% in the U.S. and less than 0.35% in all other OECD countries (OECD countries average less than 0.16%).
<i>High Share of VC investments in Early Stages</i> (see OECD 2004) - 0.36% of GNP during 1999-2002 (i.e. this means that over 50% of VC investment are devoted to early stages), compared with 0.18% of GNP in the U.S. and with 0.06% of GNP as an average in all other OECD countries).
<i>High Share of VC investments in ICT and Life Science</i> (see OECD 2004) - 0.62% of GNP during 1999-2002 (i.e. this is around 90% of VC investment), compared with 0.4% in the U.S. and an average less than 0.15% in all other OECD countries).
<i>More Than 90% of funds coming from foreign sources</i> - this includes the over 50% of VC investment coming from foreign VCs/PE organizations (see table 2) and over 75% of the Limited Partnerships (LPs) of local VCs, which are foreign (informal data).
<i>Negligible investments by domestic Pension Funds</i> – only 0.2% of the Israeli Pension Funds & Insurance Company's assets are investments in VCs (see OECD 2003), which contrasts with between 3-5% in the U.S. and Europe.
<i>A substantial share of VC entrepreneurs with S&T education and high tech background</i> – in contrast to EU during the 1990s where many VC/PE partners have financial rather than S&T/high tech backgrounds; and to the U.S. were there it is equally divided between Financial and S&T experiences. This is related to the Israeli VC industry focus on early stage finance of high tech startups (all but one of the 10 Yozma funds had at least a partner with S&T education, and only two funds didn't have any partner with direct high tech experience).
<i>Exit Channels:</i> most exits are IPOs in NASDAQ (the highest number of IPOs in NASDAQ after the U.S. and Canada - more than 120 IPOs of which 50% are VC-backed IPOs) or since 1998 acquisitions by MNEs.

Table 1a: Capital Raised by PE Organization in Israel (excluding Yozma Funds*)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
LP VCs	49	27	33	72	120	269	558	608	1548	3711	1323	52	84	724
Public VCs	0	54	22	0	0	0	29	8	45	191	6	0	0	4
Other PE	9	79	168	262	31	104	190	260	257	742	83	110	440	626
Total PE	58	160	223	334	151	373	777	876	1850	4644	1412	162	524	1354
VC/PE	84%	51%	55%	30%	81%	74%	76%	70%	86%	84%	94%	32%	16%	54%

* Yozma Funds infused to the industry \$149M in 93, \$40M in 94, \$15M in 95, \$30M in 96, and \$22M in 97.

Table 1b: Number of Active PE Management Companies with Office in Israel

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
LP VCs	3	4	11	18	21	28	35	43	50	61	68	60	58	56
Public VCs	0	3	5	5	5	5	6	6	7	7	7	7	7	7
Foreign VCs	0	0	0	0	0	0	3	8	13	17	20	19	18	17
Other PE	13	17	25	32	38	50	61	76	99	122	119	105	103	106
Total PE MC	16	24	41	55	64	83	105	133	169	207	214	191	186	186

Source: IVC 2006 and authors calculations. Public VC- Publicly Traded VC; Other PE - Non-VC Private Equity including Investment/Holding Companies, PE LP funds (directed to late stages or/and non-ICT firms)

Tables 1a and 1b strongly suggests that the creation of the Israeli VC industry (i.e. VC emergence) took place during 1993-2000 in which period the *Limited Partnerships (LP)* VC fundraising average annual growth rate was 85% and the LP VC management companies number average annual growth rate was 41%. At the same time the other segments of the PE industry experienced less dramatic growth rates (Public VCs and other PE fundraising average annual growth rate were 17% and 32% respectively). The time trends of VC/PE fundraising annual growth rates within sub-phases (see box 3) during 1991-2005 are quite interesting: during 91-92 VC declined by 23% annually while PE increased by 297%, during 93-95 VC increased by 64% annually while PE declined by 27%, during 96-98 VC increased by 67% annually while PE increased by 103%, in 99-00 VC increased by 158% annually while PE increased by 69%, in 01-03 VC declined by 72% annually while PE declined by 16%, and finally in 04-05 VC increased by 299% annually while PE increased by 112%. To sum-up while both VC and PE are influenced by underlying capital market trends, they tend to crowd-out each other (while Yozma was enhancing VC it crowded-out PE fundraising).

Table 2 clearly shows the early stages focus of the Israeli VC industry with an average of 46% investment in seed and early stages out of total VC investments. Moreover, while there are no official data for 1993-1996 the available information suggests that the share of early stage investments in those years was even higher. However, until 2002 there was an ongoing trend of decrease in seed+early stage investments and in the last 4 years these investments stabilize at an average of 36%.

Table 2: Stages of VC investment (excluding non-VC PE organization)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	Average
Seed	11%	5%	5%	10%	5%	2%	6%	8%	8%	7%
Early	57%	53%	52%	38%	41%	35%	32%	24%	28%	37%
Mid	11%	31%	28%	30%	32%	54%	49%	56%	53%	39%
Late	21%	11%	14%	22%	23%	9%	13%	12%	11%	17%

* Our (IVC) definition of 'early phase' differs from that of the OECD as summarized in Box 1. We define the Seed phase as startups at the alpha (prototype) stage, usually up to 2 years old; Early phase – startups at the Beta, initial sales stage, usually between 2-4 years old; Mid phase- start ups at the sales growth stage (usually between 3-6 years old); and Late – startups at the product expansion stage toward & after break-even point (usually between 5-10 years old and provided the startups is still 'private'). The OECD's definition would also include mid-stage in there early stage definition. Source: IVC 2006 and authors calculations.

Accompanying the process of VC emergence was the transformation of Israel's high tech industry—from a military-dominated industry to a sophisticated *startup-intensive high tech cluster* (see tables 3 & 4). Several observers have suggested that this case probably represented the most successful instance of diffusion of the Silicon Valley model of high tech (and VC) beyond North America (Bresnahan et al., 2001; Carmell & de Fontenay, 2004; OECD 2003).

Table 3: Israel's high Tech Cluster - Selected Structural Elements (1969-2005)

Accumulated Figures for a period	1969-1976	1977-1984	1985-1992	1993-2000	2001-2005
<i>Number of new high tech firms creation</i>	56	80	297	2,224	1,655
<i>Israeli LP VC (PE) Fundraised M\$</i>	0 (0)	0 (0)	~85 (~170)	7,155 (9,170)	3,533 (6,772)
<i>Number of IPOs at US & EU (VC-backed)</i>	1 (0)	13 (0)	19 (3)	133 (65)	24 (6)
Number of significant M&As (VC-backed)	0 (0)	0 (0)	2 (0)	91 (37)	53 (33)
Figure for an actual year	1976	1984	1992	2000	2005
<i># LP VC Management Companies (F-IB)</i>	0 (0)	0 (1)	5 (2)	61 (30)	58 (32)
<i>Share of ICT in Manufacturing Exports</i>	NA	14%	28%	53%	46%
<i>ICT manu. Exports M\$ (% of ICT sales)</i>	NA	900 (51%)	2,660 (63%)	11,000 (88%)	11,100 (86%)
<i>Software Development Exports M\$</i>	NA	5 (4%)	135 (23%)	2,600 (70%)	3,100 (81%)
<i>R&D as % of GDP (OCS Grants M\$)</i>	2.2% (20)	2.4% (97)	2.6% (199)	4.5% (440)	4.6% (263)

Sources: CBS (2006), IAEI (2006), IVC (2006), and OCS – Office of Chief Science (2006).

* Same of the figures in the box are from non-official sources. ** F-IB means foreign investment banks.

*** Notice that while columns 3-6 represent 8 years, column 2 represent only 5 year.

Table 4: Growth of Israeli ICT Indicators 1970-2004

	1970	1980	1985	1990	1995	2000	2002	2004
ICT (& Software) Exports (B\$)	NA	0.32	0.98	2.2	4.6	13.6	10.8	13.4
Life Science Export (B\$)	NA	NA	NA	0.04	0.21	0.70	0.98	1.92
ICT Employees (000)	NA	30.0	40.5	38.0	47.7	66.8	56.4	57.2
ICT Patents	9	20	39	87	271	417	595	617
Life Science Patents	NA	5	17	47	72	215	309	262
Total Israeli Patents	52	140	184	325	613	969	1266	1280

Source: CBS (2006), IAEI (2006), OCS (2006) ILSI (2006) and USPTO (2006).

In this paper we consider VC as an *industry*, which *evolves* over time while *co-evolving* with the high tech cluster. While we focus on the dynamic processes that enabled the VC industry and high tech cluster development, most of the VC development & policy literature emphasis capital market structure & regulation and the LP structure & contracts as the main considerations in enabling VC development (for example, Black & Gilson, 1998; Gompers & Lerner, 1998; Jeng & Wells, 2000; OECD 1996, 1997, 2000). The exceptions include a number of historical studies such as those undertaken by Florida, Kenney and others during the 1980s (Florida & Kenney, 1988a,b); some of the work of Gilson (Gilson, 2003) and of Gompers & Lerner (Gompers, 1994; Gompers & Lerner, 1999; Gompers et al., 2004); some post 2000 studies of the VC sector which are largely descriptive in nature (e.g. Bottazzi et al., 2004); and some of our previous work (such as Avnimelech & Teubal 2004a).

While the general VC literature has considered the nature and impact of the added value that VCs provide to portfolio companies (see Gompers & Lerner 1999, 2001 for a comprehensive review) it has not considered how these 'added value' abilities were developed. By focusing on comparing the performance of VC-backed versus non-VC backed startup companies (Barry, 1990, Megginson & Weiss, 1991, Brav & Gompers, 1997; Kortum & Lerner, 2000; and others) it has severely limited the extent by which the dynamic, indirect effects of VC on startups (and vice-versa) are taken into account

over time such as the foundation of new companies, reputation, generating networks and enhanced collective learning. Moreover, an industry that evolves perspective suggests that, side by side with the ‘capabilities’, ‘strategy’ and ‘organization’ of individual agents, it is important to know whether a VC industry or market has or has not emerged and what is its overall structure. These are central issues in an analysis of the impact of VC on high tech and economic growth.

Our perspective is useful for analyzing the impact of VC on an existing high tech cluster or its possible contribution to the emergence of a new one. This issue has been largely ignored in the cluster literature, which seems to consider VC as one of many Marshallian ‘input’ in the cluster formation process. In contrast to this our analysis strongly suggests that a central aspect of the impact of VC on high tech is VC-SU co-evolution (see sub-section 3.4). Through this effect, VC has been a central axis in the *emergence* of the startup-intensive high tech cluster in Israel (Avnimelech et al., 2006). It also suggests that the absence of a VC industry with strong co-evolutionary effects with startup may be a significant factor in the *non-emergence* or limited diffusion of Silicon Valley model of high tech clusters beyond the U.S. up to the 1990s.

1.1 Methodology and Data

The discovery of theory from data is accepted within the evolutionary perspective to economic change where the term ‘appreciative theory’ i.e. theory which closely follows the facts, has been contrasted to ‘formal theory’ (Nelson and Winter 1982; Nelson 1995). The methodology of this paper, which could also be considered as an example of appreciative theorizing, is known as *grounded theory* (Glaser and Strauss, 1967)-albeit one with a strong infusion of evolutionary concepts. Grounded theories are usually based on significant tacit knowledge, which has not yet been codified, written down and stored. This is central to new and/or very dynamic areas of research like the one of this paper. One of the grounded theory main purposes is to transform tacit knowledge into codified knowledge (Partington, 2000).

Grounded theory is initially mainly driven directly from empirical data. The outline of the methodological process of grounded theory is as follows. Incidents of phenomena in the data are coded into *categories* (ideally directly from the data but usually we do come to the data with some prior hypotheses). By comparing each incident with previous incidents in the same category, the researcher develops *theoretical properties of categories* e.g. links among the different variables and

categories. When it is explored in different field settings and broader contexts, it may be developed into more abstract and generalized theory (Partington, 2000).

The coding process includes three stages: *open coding* in which the data is fragmented into categories, *axial coding* in which the data is put back together in new ways using the dimensions and concepts of the *paradigm model* (cause-and-effect schema resulting from the research, which explicate the relationships between categories and subcategories) and *selective coding* in which the selected main categories are related to each other along the different *dimensions* (Strauss and Corbin, 1990). For example, in our model one of the categories is *VC-related activity*, which includes all types of finance activities of startup companies. We traced such activities along the different dimensions (e.g. phases of the model) and ascertained that through time they become more focused and eventually converged toward finance and support undertaken by formal VCs with a LP form of organization. This process is explained by the extensive experimentation that took place in such activities no less than by the demonstration effect from the successful U.S. case.

Hypotheses

We started with three general hypothesis: a) the analysis of the VC industry and of the high tech cluster should focus on dynamic processes rather than only on static ones b) VC industries emerge through cumulative processes with positive feedback; c) the macro impact of the VC industry on the high tech cluster cannot be fully calculated as a simple aggregation of VC added value to individual startup companies. Thus, our research focused both on macro and micro levels dynamic processes in the VC industry and related high tech cluster.

Data and Data Collection

The first step of data collection (during 1999-2000) included formal and informal open interviews with key agents in the Israeli high tech cluster and VC industry including four (out of the six) past Chief Sciences of the Office of Chief Science of Israel (the main government agent responsible for Innovation and Technology Policy in Israel) and important venture capitalists and entrepreneurs in Israel. The second step (during 2000-2001) involved formal semi-constructed interviews with 50 entrepreneurs from the data communication, data security chip design and other areas and 20 VC senior managers/partners of (mostly) leading VC companies i.e. theoretical sampling –

a non-random sample but a sample that served us well when analyzing the role of Yozma funds and other early entrants on the VC emergence process. During this period and afterwards we attended all IVA annual conferences since 1999 and conducted additional informal open interview with VC managers, entrepreneurs and policymakers to clarify specific issues.

The data collected in the interviews and other sources (see below) pertain to the entire high tech cluster in Israel during the years 1970-2005. It includes indicators on startup formation, closure, IPOs and M&As; VC formation, fundraising, investment and exits; and macroeconomic data on R&D expenditures, OCS grants, ICT patents, sales, exports and employees, and on MNE and Investment banks active in Israel between 1970-2005. Hand-made computations were executed to identify the structure of the VC/PE industry and to estimate the share of investments directed to 'early phase' finance and support of SU. Non-interview based data came from IVC (Israel's Venture Capital Data Center), OCS databases, CBS (Israel's Central Bureau of Statistics) databases, IAEI (Israel Association of Electronics & Information Industries) databases, USPTO (United States Patent and Trademark Office) database, NASDAQ website, and other sources.

From Description to Analysis

Starting in 2000 we undertook a systematic description of the development of Israel's VC industry and high tech cluster, and since 2001 we began analyzing this body of information in terms of the categories, concepts and theoretical properties which were finally incorporated into the paper. Several drafts and preliminary papers were written. Application of the theoretical framework developed to analyze the Israeli VC/High tech cluster case to other countries began in 2004 with a comparison to the U.S. case (see Avnimelech et al., 2005) and Israel's VC case is now beginning compared to other OECD countries (as part of a European project). Finally, increasingly after 2003 when the initial conceptual model was developed we began confronting it with related literatures in the Industry Life Cycle, Evolutionary Economics, Cluster development, VC and VC policy and learning processes areas. This confrontation process and the rich comments and suggestions by a referee led to emergence of some new concepts and properties and to the refinement of existing ones.

1.2 Specific Research Questions

Objective 1: Cast the Evolution of Israel's VC Industry in terms of an Extended ILC perspective

The theoretical framework proposed in this paper for the study of Israel's VC industry is the **Industry Life Cycle (ILC)** perspective, which will be extended to consider five phases including two phases prior to the phase of industry/market emergence. Existing ILC perspectives implicitly assume that the industry in question has been created (in fact with the first firm) and that it has traversed the full set of industry life cycle phases (see Abernathy & Utterback, 1978; Klepper, 1996, 1997; Malerba & Orsenigo, 1996 and others). The theory does not *explain* the emergence of a new industry. This is particularly worrisome in the case of early stage VC industry. Unlike many other industries where international diffusion beyond the innovator country was widespread, the emergence of a significant early stage VC industry (the VC strict definition) beyond the U.S. till the year 2000 was limited, Israel being an outstanding example. This constrained pattern of development (despite frequent attempts by Governments to foster such an industry, see OECD 1996, 1997, 2000 and 2003) contrasts with the growing recognition of the importance of VC for the successful exploitation of the ongoing ICT revolution and the development of a successful high tech clusters (Carpenter & Petersen, 2002; Kortum & Lerner, 2000).

In this paper we explicitly link the various phases of VC evolution to evolutionary mechanisms i.e. Variation, Selection, Reproduction and Development (V-S-R-D).

Objective 2: Further Characterize the VC industry/market Emergence Process

The cluster development literature (e.g. Bresnahan et al., 2001, Feldman, 2001; Fornhal & Menzel, 2004; Maskell, 2001) and our previous work on the evolution of VC in Israel (Avnimelech & Teubal 2004a,c) strongly suggest that emergence involves static and *dynamic increasing returns*. Dynamic increasing returns follow from emergence being a cumulative process with positive feedback such that an increase in the level of activity (and profitability) at time **t** will, at least for some time, lead to further increases in activity and profitability after **t**. Some of the sub-processes explaining cumulativeness e.g. enhanced reputation of the VC industry as a whole as a result of a few successful exits, involve the increasing availability of positive external economies i.e. the dynamic increasing returns involve a *social* rather than exclusively a *private* component (Bresnahan et al., 2001).

Our objective is to identify individual sub-processes, which operated during VC industry emergence in Israel and to ascertain whether and how they led to a cumulative

process with positive feedback. We also introduce, and illustrate for the Israeli case, the related notion of '*Emergence Profile*'. For lack of data it is impossible at this stage to model such processes in a meaningful way. Still, we think that our largely qualitative analysis will frame the issue in a realistic and useful way, and possibly influence the types of new microeconomic data to be collected. Another related issue is the notion of '*Emergence State*'¹. When can we state that a new *industry/market* have been created? This question seems not to have been thoroughly discussed in the literature². Without providing a full analytical characterization, we will re-consider this notion providing some empirical counterparts for the VC case.

2. An Industry Life Cycle Model of VC Industry Evolution

Our ILC model is a particular variant and extension of the classical Product Life Cycle model (Abernathy & Utterback 1978; Malerba & Orsenigo, 1996; and to some extent Klepper 1996, 1997 and Jovanovic & MacDonald, 1994), which is most suitable for the analysis of an industry's evolution. It differs from the conventional ILC in that it is designed to fit the VC industry- a 'service' industry with unique characteristics (including a cyclical behavior-see Gompers and Lerner, 2002; Lerner, 2002) that represent a private infrastructure or a complementary asset (Teece, 1986) to high tech startups. In contrast with Abernathy & Utterback's three phases and Klepper's dynamic analysis, it consists of five well-determined phases of evolution (two before and two after industry emergence). The model is linked to the analysis of technological revolutions (Freeman & Perez, 1988; Perez, 2002) and to the analysis of high tech cluster development (Feldman, 2001; Bresnahan et al., 2001; Fornhal & Menzel, 2004).

For our purposes an industry is a '*social institution*' and a '*sectoral system of innovation*' (Malerba, 2005) one normally embedded in the country's National Innovation System and oriented towards the supply of a particular class of products/services. It is constituted by a number of distinct components: *firms, supporting organizations* e.g. Universities and Technological Institutes; *institutions* e.g. standards and arbitration; and *networks, interactions and links*. An industry is more than one firm

¹ From the several definitions of emergence from the natural sciences the following one seems to be closest to our view: "Properties of a complex physical system are emergent...in case they are neither properties had by any parts of the system taken in isolation, nor resultant of a mere summation of properties of parts of the system (Peter Mandik in www.artsci.wustl.edu/~philos/MindDict/E.html)

² The focus in the traditional Economics Literature seems to be on market imperfections or 'missing markets'. In such perspective the existence of a particular market transaction would seem to imply that the underlying market exist. Alternatively we could refer to 'market building' and consider when a market exists. Accordingly, the existence of individual transactions does not constitute proof that a 'social institution' called 'market' exists.

and more than a set of un-connected firms supplying a new class of products or services, it represents a higher level of organization than that of the individual agent or firm. Market and non-market relations among the firms of an industry and between them and their customers and suppliers, are significant aspect of an industry.

The function of a new industry (and a of new market) is to promote specialization and division of labor, and through these, economic growth. When a new product class is supplied by a new industry its future availability is greatly assured at least compared to a single firm and even to an agglomeration of firms. Alternatively, relative *stability of supply* should be a defining characteristic of a new industry. The relevant entity must also be of a certain size for it to be called an industry: this will enable it to exploit economies of *scale and scope*. Some of these industry level economies will induce geographically determined cluster effects leading to the supply of a variety of inputs (in close proximity to the operation of firms). For these scale effects to be operative the relevant entity must have achieved *critical mass*.

A new industry is an *emergent structure*, the outcome of ‘collective behavior’ of pre-existing interacting agents or elements or components (Odell, 1998). This behavior leads to an *emergence process*³. For our present purposes this process, like many other evolutionary processes involving post-selection development/reproduction (Aldrich, 1999), should be characterized as an *auto-catalytic, cumulative process with positive feedback*.

Alternatively it can be stated that the process of emergence is characterized by *dynamic* economies of scale (in addition to the static economies of scale that operate also in mature industries); and that it involves creation and utilization of externalities. This process does not end with creation of the new industry; rather it continues afterwards at least for a time (and provided that external conditions do not deteriorate) in an auto-catalytic fashion. The new and more complex structure i.e. industry- created by the interaction among its components (firms and institutions)- will, once emerged, positively further stimulate such components, at least for a while (see also Saxenian, 1998 and Fornel & Menzel, 2004).

2.1 Phases in the Evolution of the VC Industry

³ For additional characterizations of emergence properties and structures in the context of complexity theory see Kauffman (1995), Bar-Yam (1997) and Foster & Metcalfe (2001).

The model developed here analyzes the evolution of VC industries together with the associated startup-intensive high tech clusters. It contains five phases each one comprising critical events/processes (Box 2 & 3) and *Variation-Selection-Reproduction-Development (V-S-R-D)* evolutionary mechanisms (Box 4).

At the *background conditions phase* (phase 1, 1970-85 in Israel) there is no startup-intensive high tech cluster since neither a significant startup segment nor a specialized VC segment will be operating in this phase. During this phase the S&T fields in the academia will continue to develop as well as specialize labor force and a segment of R&D performing firms will be created (in Israel, a direct result of the very successful grants to business sector R&D policy which started in 1969). In this phase a number of critical events and processes pertaining to the technological and financial infrastructure for the future VC industry will be established. These include the development and diffusion of R&D/innovation capabilities in the business sector, the beginning of global product and capital market links, creation of a favorable environment for foreign investment (for non-U.S. cases), the gradual involvement of financial institutions in high tech; and the very first steps of technological entrepreneurship activity. Parallel to this 'policy capabilities infrastructure' will be developed (see Avnimelech & Teubal, 2005).

At the *Pre-Emergence* (phase 2, 1986-92 in Israel) a VC industry with a clear identity does not yet exist although some (mainly informal) VC activity takes place. A central feature is the appearance of significant startup activity and the gradual acceptance of technological entrepreneurship. A critical mass of startups will have been accumulated towards the end of this phase and, correspondingly, a measure of 'demand' for the VC services. Also, significant startup and VC-related experimentation and learning will take place (variation). This leads towards the end of the pre-emergence period to a narrowing of variants (selection) of critical parameters of the future market and industry. Thus, while the startup-intensive high tech cluster has not yet emerged some of its central qualitative characteristics will take hold e.g. the 'born global' business model; LP VC organizations are identified as most suitable to finance and support start ups, and some high tech fields will appear to enjoy a sustainable competitive advantage.

VC Emergence (phase 3, 1993-2000 in Israel) is reflected in the rapid quantitative growth of VC and startup activity and the eventual emergence both of a VC industry and of the startup-intensive *high tech cluster*. It begins with a *fluid sub-phase* (1993-

1995 in Israel) followed by an accelerated *rapid growth process* (1996-1998 in Israel) that eventually leads to *overshooting/bobble* (1999-2000 in Israel).

During the *fluid* sub-phase significant experimentation and collective learning takes place both with respect to VC strategies and with respect to VC organization. Many strategies, routines and organizational forms do not survive; some do and are adopted by varying numbers of VCs. Their distribution is not 'stable' yet. In addition from competing with each other, VCs also cooperate (a typical characteristic of young markets). At the end of this sub-phase, the *Limited Partnership* form of VC organization, the *ICT focus*, and the *early phase investment strategy* became dominant among VCs; while a 'born global' strategy and an exit mechanism through an IPO in NASDAQ was becoming standard among startups.

During the *rapid growth* sub-phase we observe an accelerated entry of new VC companies fed by a cumulative process with positive feedback effects. A domestic VC industry will be created (the 'state' of emergence). It is then that the industry attains a size, which enabled it to sustain a large number of supporting services (e.g. National VC Associations, specialized attorneys, lawyers, and IP offices). This induces entry of additional domestic VCs and of foreign VCs; rapid creation of startups and rapid growth in the acquisition activities of MNCs. As long as external and internal conditions remain unchanged, the process of creation and growth of large numbers of new startups will continue and a *startup-intensive high tech cluster* will have emerged.

At same point of time the industry/cluster enters the *overshooting/bobble* sub phase followed by an investment crisis/boast. There are two different concepts of VC *industry* crisis: a domestic crisis associated with the evolution of the industry; and a global *investment crisis* flowing from global capital and technological markets cycle downturn. The first, which is relevant to our evolutionary industry development model, is a consequence of the industry having achieved a certain size— a *System Fitness crisis*. The second concept of crisis is linked to the empirically observed over-investment in specific technologies at specific period (so-called bubble), which is a process that repeats itself every few years in capital markets in general and in VC investment in particular (Lerner, 2002). Gompers & Lerner (2002) presents 4 such VC crises between 1978 and 2001. The post-emergence crisis is usually triggered by and parallel to an bubble. However, the post-emergence crisis actually jeopardizes industry survival; and even when the industry survives its structure may change dramatically (Gompers, 1994).

The fourth *Restructuring* phase, which is a response to this crisis, encompasses not only the VC industry but also the whole high tech cluster. *Restructuring* involves new patterns of interaction within the cluster and new links between the high tech cluster and the rest of the economy. During this phase new strategic groups within the VC industry (defined by structure, capabilities and strategy e.g. Corporate VCs, Foreign VCs, Specialized/ Non-specialized domestic VCs, Bank affiliated VCs, etc.) are created and new forms of PE agents are developed. The industry may re-focus towards later stages and fewer technological areas in-order to reduce risk (Gompers, 1994). Policy is likely to play an important role in the successful restructuring of VC industries and in the subsequent *Consolidation* (phase 5). By then, the core of the industry will consist of those VCs that survived the crisis. This last phase will also be characterized by a relatively stable set of PE segments and to some extent the industry is expected to become more stable in terms of capital raised and invested.

Box 2: Main Characteristics in the Evolution of a VC Industry/High Tech Cluster

Background Conditions Phase	<ul style="list-style-type: none"> • Creation of High Tech Industry and R&D/ Innovation capabilities; • National concern for the financing of SME not necessarily high tech startups. • No (or insignificant) formal VC activity; limited informal VC activity. <p>→ <i>The startup-intensive high tech cluster does not exist yet.</i></p>
Pre-Emergence Phase	<ul style="list-style-type: none"> • A Technological Revolution that assures a continued stream of new business opportunities for startups. • A significant increase in the supply of potential high tech employees. • Growing acceptance of entrepreneurship and new mechanisms for supporting startups. • Increasing numbers of startups → creating excess demand for VC services • Growth of informal VC, e.g. angels & VC-related activities; and some formal VCs. • Experimentation (variation) & Learning by SU, VCs and Policy makers. <p>→ <i>Some important qualitative aspects of the future entrepreneurial cluster are getting established e.g. patterns of specialization (software and communication in Israel) and VC & SU organizational forms. Also a quantitative jump in the number of startups.</i></p>
Emergence Phase Early Emergence	<ul style="list-style-type: none"> • High rate of growth of VC & SU activity; large numbers of new VC & SU companies • Continuation of Experimentation by VC & SU agents → Enhanced Selection • VC-SU Co-evolution process: a Cumulative growth process caused by positive feedbacks, collective learning, scale economics and network effects. <p>→ <i>Cumulative process of emergence of the startup-intensive high tech cluster, with a large component of quantitative growth.</i></p>
Late-Emergence	<ul style="list-style-type: none"> • Entry of less skilled VC & SU agents, excessive competition and overshooting
Crisis & Restructuring	<ul style="list-style-type: none"> • The overshooting leads to a crisis characterized by the drying-out of the sources of capital, by a shakeout of VC & SU, and by operational cutbacks and fire sale of startups • A new set of institutions (formal and informal) emerge and a new set of policies are implemented • Restructuring of the VC industry and the EHTC through collective action/interaction leading to the emergence of a new set of institutions. Restructuring success depends on the length and strength of the emergence process, and on the new institutional framework. <p>→ <i>Significant changes in the structure of the startup-intensive high tech cluster, in its supporting institutions, and in its interaction with the entire cluster.</i></p>
Consolidation	<ul style="list-style-type: none"> • The major effect of restructuring is <i>sustainability</i> of the VC industry; the enhanced capacity to overcome crises, and the survival mostly of high quality VC and startups. • At this phase the cluster became more diversified and the VC industry tends to spread to later stages of investment, and a related PE industry is expected to grow.

Box 3: Phases in the Evolution of the Israeli VC Industry/Startup-Intensive Cluster

Phase (sub-Phase) in VC Evolution	Period, Israel
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<i>Background Conditions</i>	1970-85
<i>Pre-Emergence</i>	1986-92
<i>Emergence (Fluid, Growth, Overshooting)</i>	1993-2000 (93-95, 96-98, 99-00)
<i>Crisis and Restructuring</i>	2001-2004
<i>Consolidation</i>	2005-

2.2 Casting High Tech Cluster Dynamics in Evolutionary Terms

In order to interpret box 4 it is important to recognize that the application of the V-S-R-D principles to our analysis of phases can be complex, since the entities or populations to which they are applied change, partly as a result of past events⁴. Israel's *R&D performing firms in the business sector* were the "original source" of what later became the *startup-intensive high tech cluster* of which VC and startup companies are part. With this perspective, the diffusion of R&D and of innovation to firms in the business sector during the *background conditions* phase represented "variation" in an evolutionary sense. This process led to the emergence of a distinctive *high tech industry* during the first half of the 1980s, one oriented to electronics and instrumentation in general ("selection" and "reproduction and development").

During the *pre-emergence* phase a process of variation within the high tech population of firms took place. The relevant set of characteristics involved specific high tech areas or sectors, types of firms (incumbents versus startups) and startup characteristics. This led to selection and a measure of reproduction and development of software and other ICT areas and of critical characteristics of startup organization and strategy (e.g. the 'born global' strategy). Also, variation took place in connection with types of proto-VC agents & organizations e.g. angels, investment banks, affiliated and independent VC organizations, etc. This led to selection of the domestic VC organization as the appropriate startup finance and support mechanism.

During the *emergence* phase we observe further selection (in Israel e.g. a strategy oriented both to global product and to global capital markets) and further reproduction/development of the startup segment; selection of the LP VC organization followed by reproduction/development leading to VC industry emergence. At this point the new *startuo-intensive cluster* is actually being established. The last two phases (*restructuring* and *consolidation*) contain aspects of re-fluidization and diversification of the cluster, and therefore trigger new cycles of V-S-R-D at various levels.

⁴ The relevant population of agents is, successively throughout the ILC, the Business Sector, High Tech Sectors, the Startup Segment, the VC Industry and the Startup-Intensive High Tech Cluster.

Box 4: Specific V-S-R-D mechanisms at the startup-intensive cluster evolution in Israel

Triggers to Background	<ul style="list-style-type: none"> • Military R&D and the creation of high tech industries became national strategic priorities after 1967. The OCS (in charge of providing subsidies to business sector R&D) was created in 1969.
Background 1969-85 Focus on the Business Sector	<ul style="list-style-type: none"> • <i>R&D-related variation within business sector</i>– Experimentation with R&D/Innovation projects in the business sector and experimentation in financing them by the OCS; establishment of semiconductors MNE in Israel; extensive military R&D performed by Defense organizations; learning how to leverage R&D to access complementary assets for export market penetration; and initiation of global links • <i>Selection & R/D</i>– an electronics and instruments-related high tech sector
Pre-Emergence 1986-92 Focus on the High Tech sectors and SU segment	<ul style="list-style-type: none"> • <i>Variation within the high tech sector & with international links</i>. This primarily relates to startup creation and characteristics; to high tech areas of activity; and IPO attempts of incumbent companies and SU. Also concerning types of informal and formal VC organizations and agents. <i>Selection</i> of the independent, domestic VC organization • <i>Selection & R/D</i> of the software industry and other high tech areas; of the innovative startup model. Also, establishment of specific links with U.S. HT and capital markets
Emergence 1993-2000 Focus on the new Cluster	<ul style="list-style-type: none"> • Further <i>Selection & R/D</i>– of the born global high tech startup model and specific ICT technologies that fit it; of the LP VC form and the focus on early stage investments; and of the links with NASDAQ (through U.S. investment banks) and with U.S. high tech MNC. • <i>R/D</i> – led to emergence of the VC industry and the new startup-intensive cluster.
Restructuring 2001-04	<ul style="list-style-type: none"> • <i>Selection and R/D</i> (within VC-SU) – of VC strategic groups and related specific VCs’ capabilities and strategies; of more specific startup business models and strategies; of new types of VC syndication.

Links to Three-Stage Evolution

The above analysis of evolutionary processes is close to Foster & Metcalfe’s *Three Stage Evolution* scheme based on ‘Selection’ and ‘Development’ on the one hand and ‘Structural & Qualitative Change’ on the other (Foster and Metcalfe 2001, pp. 9-14). ‘Selection’ in their context includes our variation & selection; while ‘Development’ comprises processes, which revise, add or subtract from the distinctive units of selection of the population⁵. This contrasts with the simpler, more traditional *Two Stage Evolution* scheme involving ‘selection’ on the one hand and ‘structural change’ in the other. In two-stage evolution, the characteristics of the selection units are exogenously given and ‘processes of competitive selection necessarily destroy or rather absorb the very variety on which evolution depends’. Unless this variety is replenished, evolution will come to an end.

There are a number of reasons for affinity between our model and the three-stage scheme. We now refer to some of them:

(i) *Variation is endogenous*. We have mentioned several mechanisms e.g. grants to business sector R&D in phase 1, search for/experimentation with new modes of

⁵ In the three-stage evolution model Qualitative and Structural Change are the outcomes of Selection and Development, with Development also directly affecting Selection (Foster & Metcalfe 2001, p.6, figure 1.1). The direct link with Qualitative change is the reason why, in our scheme, post selection processes relate both to reproduction of previously selected agents and to the emergence of new & more complex) ones (development).

financing and supporting startup, and search/experimentation for organizational forms of VC or VC-related organizations (phase 2, 3);

(ii) ***Variation and Selection are inseparably or are mutually linked.*** Inseparability has been strongly emphasized by Noteboom (2001). In our model we emphasize links e.g. what is selected may undergo a subsequent V-S round. Thus in the last example above—an independent & domestic VC which is ‘selected’ in phase 2 subsequently undergoes a process of variation concerning organizational variants e.g. public VC company or LP;

(iii) ***Qualitative Change:*** the result of selection and development is not only structural change involving a given set of sectors but the addition of a new VC industry and/or a new VC market. Qualitative change will include emergence more complex forms of organization and new, system level, properties, and etc.;

(iv) ***A non linear process:*** in contrast to two stage evolution V-S-R-D in our model occurs in all phases, some of it in the form of ‘nested cycles’.

2.3 Conditions for Phase Transitions

Any cycle model should explicitly consider the conditions for phase transitions. In our case these have two components: the qualitative factors mentioned in Box 2 and the intensity or strength (quantitative measures) of at least a subset of these factors.

From Phase 1 to a Successful Phase 2

A major condition (phase transition) to the second, *Pre-Emergence* phase is significant diffusion of R&D and associated innovation capabilities throughout the business sector⁶. This is necessary for a country to be able to transform-through R&D and innovation—a pool of technological opportunities into a stream of potential business opportunities. A related condition is an ongoing *Technological Revolution* that would make the pool of technological opportunities continuously renewable. Both conditions, and the creation of a distinctive high tech industry, are aimed at supporting the creation of a mass of startups during Phase 2, which is a critical factor for a successful pre-emergence phase.

From Phase 2 to a Potentially Successful Phase 3

Transition to a successful *VC emergence* process (Phase 3) involves two groups of conditions: first, those underpinning early Phase 3 ‘demand’ for VC services; second, those underpinning rapid growth of *VC supply*.

⁶ The R&D capabilities created in phase 1 need not be focused on startups exclusively as long as incumbent R&D performing companies’ capabilities could subsequently be transmuted into new startups through spin-offs (see Klepper 2001, 2002).

An adequate ‘demand’ for VC services early during Phase 3 is a result of the appearance of a critical mass of startups during late Phase 2. The factors stimulating VC ‘demand’ (i.e. the pool of startups) are both ‘internal’ (domestic) and ‘external’ to the economy. For Israel, domestic factors included e.g. creation of a separately identifiable software industry during the 1980s; the restructuring of (and spin-offs from) large civilian oriented companies and of Defense oriented industries; a cultural shift favoring technological entrepreneurship; identification of areas of sustainable competitive advantages within Israel’s ICT sectors, and continued R&D support for high tech startups⁷. ‘External’ factors stimulating ‘demand’ include the growth in global markets for ICT products, deregulation of communications markets; ‘globalization’ of capital markets for technology companies (NASDAQ); a significant growth in global acquisition activities of MNEs; etc.

The ‘Supply’ side’ conditions for a transition to the VC emergence phase includes domestic liberalization of capital markets e.g. to create conditions for foreign flows of funds to the country, and other institutional adaptations e.g. of bankruptcy laws and of company or commercial law to make possible the foundation of LPs, and of accountancy procedures and routines to make them SEC compatible. These would pave the way for a rapid phase 3 ‘supply response’ through inflows of funds from domestic financial & other sectors and private investors, from the global PE industry or other foreign sources, and from Government funds as part of a targeted VC program.

3. Characterizing Venture Capital Emergence

3.1 Acceleration of VC activity

The Israeli VC industry was created during the process of VC emergence (1993-2000). The VC ‘*emergence state*’ materialized during the second sub-phase of VC emergence (1996-1998). This phase was characterized by accelerated growth of VC activity; by entry of large numbers of players both on the supply side (VCs) and on the demand side (startups); and by ‘selection/reproduction’ of critical features of the industry. Table 5 shows figures on VC fundraising & investment, on startup creation & exits (IPOs & M&As). The *direct* impact of Yozma is reflected in numbers of new VC-

⁷ In Israel Government support of business sector R&D started in Phase 1 and was a main factor in the diffusion of R&D throughout the business sector. During phase 2 this program was expanded and adopted more startup. This contributed to the VC ‘demand’ conditions required for a transition to the VC emergence phase.

backed startups and VC-backed exits. The indirect impact also includes the acceleration of startups formation and the general increase in startups' exits.

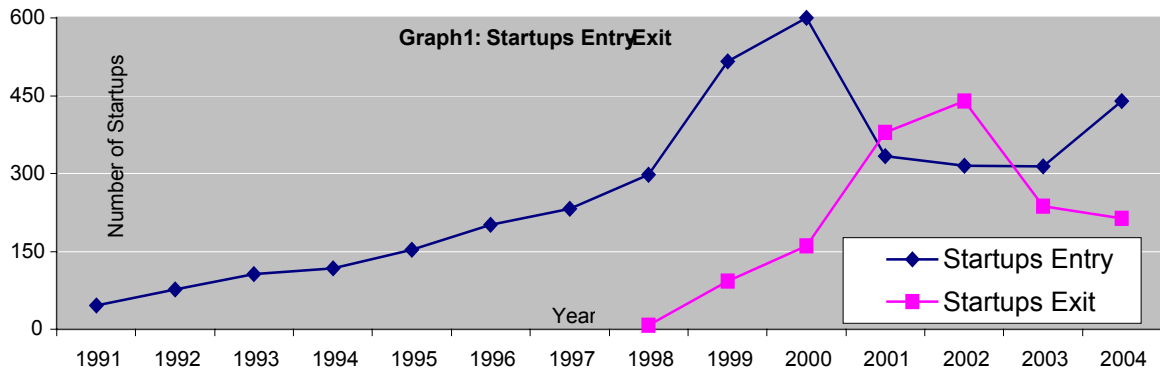
Total IPOs increased considerably during 1995-2000 compared to 1991-94. A related point is the increase in the share of VC-backed issues. The picture, which emerges, is one of increasing maturity of Israel's high tech industry (due to learning and other cluster effects such as the creation of the VC industry itself), a process that is accompanied by the increase in the NASDAQ index (Both factors were certainly at work here - although NASDAQ index growth itself induce an increase in IPOs, it did not induce other countries' high tech clusters to float more). The picture about the emerging high tech cluster will not be complete without considering the phenomenon of M&A—one of the main mechanisms of exit for VC companies, for startup entrepreneurs and for other investors. There is no clear 'market place' where M&A transactions are negotiated and implemented i.e. they are 'private' rather than 'public' capital market transactions. It follows that the conditions for an emerging cluster to facilitate M&A activity on a *continuous basis* differ from those required to provide access to public capital markets. A clear “demonstration and reputation effect” (Kreps & Wilson, 1982) is required in order to trigger MNCs to undertake costly search for technological opportunities in a specific cluster (Barry et al., 2003). The Israeli case suggests that IPOs might play a crucial role in creating the conditions for cluster emergence and that M&A only come in stream in increasingly large numbers later on (became significant only in 1998). The link could be as follows: public capital market links early in the game generate conditions for the emergence of a distinctive VC industry and a reputable high tech cluster. The new industry develops the capabilities and reputation for M&A deals. With the onset of cluster maturity and with enhanced cluster reputation, MNCs start to search for technology opportunities in the cluster and this creates an even stronger wave of M&A.

Table 5: VC Raised/Invested and High Tech Startups Foundation, IPOs and M&As

Year	VC Raised (Total PE)	VC Invested (% Foreign)	High Tech Startups Foundation (VC Backed)	High Tech SU IPOs in NASDAQ (VC backed)	High Tech SU IPOs in Europe (VC backed)	Significant High Tech M&As (VC backed)
1990	5 (NA)	NA	48 (4)	1 (1)	0 (0)	1 (0)
1991	49 (58)	NA	46 (9)	4 (1)	0 (0)	0 (0)
1992	81 (160)	NA	76 (21)	9 (1)	0 (0)	1 (0)
1993	204 (372)	NA	106 (74)	11 (4)	0 (0)	1 (0)
1994	112 (374)	NA	117 (87)	8 (4)	1 (0)	2 (2)
1995	135 (166)	NA	153 (84)	9 (4)	2 (0)	7 (3)
1996	299 (403)	NA	201 (98)	16 (10)	3 (1)	11 (3)

1997	609 (799)	440 (43%)	232 (119)	12 (3)	0 (0)	7 (3)
1998	616 (876)	589 (44%)	298 (152)	7 (4)	6 (1)	16 (6)
1999	1,593 (1,850)	1,011 (57%)	516 (208)	12 (9)	6 (1)	15 (9)
2000	3,902 (4,644)	3,233 (59%)	601 (372)	19 (12)	13 (3)	32 (11)
2001	1,329 (1,412)	1,985 (59%)	333 (159)	2 (1)	0 (0)	8 (6)
2002	52 (162)	1,138 (58%)	315 (76)	1 (0)	0 (0)	5 (3)
2003	84 (524)	1,011 (58%)	314 (113)	0 (0)	0 (0)	9 (8)
2004	728 (1,354)	1,465 (55%)	439 (141)	6 (2)	1 (0)	15 (7)
2005	1,052 (1,980)	1,339 (51%)	242 (120)	4 (2)	11 (1)	16 (9)

Source: IVC Database 2005 and authors calculations.



3.2 A Policy-led process triggered by a Targeted Program (Yozma)

Israel's Yozma program successfully targeted the VC industry in Israel by sparking a cumulative process leading to the emergence of the industry during 1993-2000. Government money (\$80M) seeded 10 hybrids funds ('Yozma Funds') and an additional \$20M was directly managed by a Government-owned fund ('Yozma Venture Fund'). Government's contributed leveraged an additional \$150M mostly from reputable financial institutions and corporations from abroad and from Israel. This initial infusion of funds was invested in approximately 200 startups.

The background to this program was a set of new national priorities, which emerged in the late 1980s and early 1990s in the wake of changes in the external and internal environments of Israel. First, during the second half of the 1980s the Military industries laid-off hundreds of engineers and many startup companies were created only to subsequently fail. Second, the massive immigration from the former Soviet Union during the early 1990s spurred the Government to search for means to employ the thousands of engineers that came to this country. Third, the grants to business sector R&D program, which was the backbone to Israel's innovation policy since 1969, was increasingly perceived as being ineffective. The Government concluded that the problem was not only lack of resources for the post R&D phases of the innovation process in companies but also lack of management and marketing capabilities. It

spurred a problem solving process, which led to the identification of VC and support of startups (rather than simply ‘R&D additionality’) as the new Innovation & Technology national priorities. The outcomes were two VC directed programs—a failed precursor program (Inbal) and the successful Yozma program (implemented during 1993-7). Yozma’s design played a crucial role in explaining its differential performance since both programs had almost similar goals and their date of initiation differed by only one year with a 5 years overlap in implementation. Boxes 5-7 summarize the characteristics of the Yozma program and differences designs, goals and outcomes between Yozma program and Inbal program.

The new infusion of VC triggered a cumulative process with positive feedback in which more and more profitable VC activity ‘today’ spurred even more and more profitable VC activity ‘tomorrow’. At the center of this process was VC-SU co-evolution. Other dynamic processes were involved as well such as i) entry of strategic investors in response to the early reputation earned from some excellent Yozma Funds' portfolio company exits during 1996-8; ii) this in turn extended the Israeli VC industry networks and added value abilities; iii) cluster effects enabling a wider set of VC/high tech non-tradable services to be available locally (e.g. lawyers, financiers, accountants and consultants); iv) entry of MNCs into the cluster and continues stream of acquisitions by MNCs, which also extended the cluster’s networks and capabilities; and v) collective learning concerning the VC business, etc.⁸

Box 5: Critical Dimensions of Yozma Program Design

Promoted by the OCS and Structured Fund of Funds (& Direct investments);
Target Level of Capital Aimed at 250M\$ (Government Support- 100M\$).
10 Privately owned Israeli VC Funds each managed by a local management company (formal institution) & involving Reputable Foreign Financial Institution.
Government Participation in each Fund- \$8M (up to 40% of fund’s capital)
Strong Incentive to the “Upside”- a 5-year option to buy the Government’s share at cost.
No Government intervention in the day by day operation of Yozma Funds
Planned ‘Privatization’ of Yozma Fund & Program: Privatization was completed in 1998. Yozma became a Catalytic Program.

Box 6: Factors Explaining the Differential Yozma-Inbal Impact

YOZMA	INBAL
The program was structured as Fund of Funds (equity investments in the hybrid funds).	The program was structured, as a Government Insurance company (guarantees to the funds)
Single Objective: Creating a VC industry	Dual objective: Promoting the local stock exchange and a VC industry.

⁸ There is evidence that because of these cumulative effects and the growth of NASDAQ index during the relevant period – Government VC equity and investments did not ‘crowd out’ private VC investments as expected from the neoclassical perspective. In fact the opposite was the case: by triggering a cumulative process of growth, it led to the creation of new business opportunities, which the private VC sector exploited (see Avnimelech & Teubal 2004c).

LP form of VC-the ideal form of organization according to U.S. experience.	Publicly traded form of VC; hard to leverage current success to fundraising and bureaucracy.
Investments focused on early stages	Investments also in later stages and non-high tech
Strong incentive to collective learning, to VC cooperation, and to 'learning from others' (through requirement of having a reputable foreign financial institution)	No incentive to collective learning, to learning from others or to VC cooperation. Did not attract any new global financial nor strategic investor into Israel
The Government owned fund started to invest immediately - encouraged VCs to invest fast.	No mechanism to encourage VC firms to invest immediately
In addition to administrative criteria, Managers' abilities were an important criterion for selection of 'Yozma Funds'.	Administrative and financial criteria figured prominently in selection of Inbal VCs (there being no assurance of existence of specific VC abilities).
Limited number & period of Yozma funds-created an incentive to join fast; and clear and easy way out of the program.	No explicit limit to the number & timing of funds that could enjoy the INBAL benefit; and complex way out of the program.
Leveraged Incentives to the Upside. Attracting professional VC teams.	Downside guarantees, which favor entry of non-professional VC firms

Box 7: Comparison of Yozma-Inbal impact

YOZMA	INBAL
Created a critical mass of VC investment	Critical mass of VC activity was not achieved
Most 'Yozma fund' are among the 20 leading VCs in Israel	Non of the INBAL fund are among the 20 leading VCs in Israel
Very high private VC performance	Low private VC performance
Follow up funds & strong growth of capital	Very few secondary issues
Yozma Funds were models for the design of many other VC companies in Israel	Very few other public traded VC were established in Israel

For further analysis of the impact of Yozma see Avnimelech & Teubal 2004b, 2005

From an evolutionary perspective it is important to consider not only programs like Yozma, which were successful but also precursor programs (like Inbal) which, even though they failed to generate a VC industry, nonetheless 'indirectly' promoted the successful program. The Inbal Program was the first attempt at targeting the VC industry. It was launched in 1992 one year before the implementation of Yozma. Its central idea was to stimulate *publicly traded* VC funds by guaranteeing the Downside of their investments. The mechanism used was a Government Insurance Company ("Inbal") that guaranteed VC funds traded in the Israeli local stock market (TASE) up to 70% of initial capital assets. The program imposed certain restrictions on the investments of the VC companies covered by the program. Four (4) funds were established. They and the Inbal program as a whole were not a great success. Inbal fund valuations in the stock market were low, similar to Holding Companies' valuations. Moreover, the funds encountered bureaucratic problems and had to go to great lengths in order to prepare regular period reports. Eventually all of them attempted to leave the program, which they eventually did. The funds did not succeed financially and did not

grow. Today all the (former) Inbal Funds are 'held' by one holding Company (Green Technology Holdings).

Inbal supported publicly traded VCs with guarantees to the downside. There was no mechanism for drawing professional agents with VC abilities into the program; it did not generate VC companies with adding value capabilities (including those coming from investors); and it was exposed to 'stock market sickness' and short-term thinking. While the organizational model of VC company organization was not imitated, the 'social impact' of the program was probably not low. Our interviews reveal that policy makers and businessmen alike learned from Inbal's weak impact: the difficulty in publicly traded VCs of having investors contribute to the operation of the fund; greater difficulty to rapidly exploit reputation earned from early exits in order to raise new capital; limits on management decision making flexibility and on management compensation; and last but not least- absence of incentives for the “upside” (an important factor in attracting professional VCs). We conclude that the indirect contribution of Inbal to the eventual adoption of a successful VC policy in Israel was quite high (also, it apparently did have an effect in Yozma's ‘selection’ of Limited Partnerships as the form of VC organization which that program would promote).

3.3 Multi-component Cumulative Effects

The ‘Yozma Funds’ triggered a cumulative process that comprised a number of linked sub-processes, which are listed in Box 8. Overall, the first ones in the box started operating before the later ones; and at least for a time, each new sub-process increased the set already in operation thereby reinforcing the cumulateness of VC emergence.

A central motivation for the operation of these sub-processes is *expected profitability* although *strategic considerations* were also important⁹. Some of these sub-processes jointly acted to determine a process of VC-SU co-evolution-- a major distinctive feature of the re-configuration of Israel's high tech cluster during the 1990s.

A major issue suggested by the dynamic sub-processes presented in Box 8 and by the context in which they operated is Israel's VC emergence *profile*. This would include characterizations of critical pre-emergence conditions, of what sparked the emergence process, and of the central events and sub-processes that sustained emergence. As an example of each one of these three categories or sets of events, the

⁹ As the reputation of the cluster was increasing, most ICT world-class players had to have some sort of presence in Israel e.g. through corporate VC funds or as LPs of Israeli VCs or the establishment of an R&D facility in Israel.

profile will be characterized by a critical mass of startups which proceeded the onset of cumulateness, a targeted Government program involving a capital contribution directed in a dominant way to a Fund of Funds function; and VC-SU co-evolution which seems to have been a central vector in the emergence process.

Box 8: Sub-processes operating during VC emergence

1. Yozma Funds and other LP VCs founded prior to 1996 <i>created follow-up funds</i>
2. Entry of non-Yozma LP VCs during 96-98 and <i>follow-up funds</i> of these organizations
3. <i>Successful Exits of these early entrants enhanced their Reputation and eventually, the Reputation of Israel's VC and high tech industries.</i> This led to more VC fundraising.
4. Among these we have <i>new Strategic Partners</i> e.g. IBM, Cisco, Intel, Nokia, AOL, etc. as Limited Partners of Israeli VCs. This in turn led to further <i>Reputation and Networking</i> of portfolio companies, which further strengthened their activity and performance. It also led, in some cases, to <i>enhanced direct investments</i> by such partners and to enhanced reputation and networking benefiting the VC industry/ high tech cluster as a whole
5. During the process, <i>foreign investment banks set up offices in Israel.</i> This <i>further facilitates the creation and growth of high tech startups</i>
6. <i>Collective Learning</i> of the VC industry and Interactive Learning involving both VCs and SU (see VC-SU co-evolution below)
7. <i>“Cluster Effects”</i> from the higher scale of activity which enhanced the local production of inputs and services for the VC/high tech sector (e.g. accounting, consulting, legal, etc)
8. Significant direct foreign VC/CVC activity in Israel, starting in 1997 (represent 50-60% of the VC investments in Israel). Some foreign VCs established domestic offices in Israel, starting in 1999

3.4 VC-SU Co-evolution

The variables influencing VC ILC are related among themselves within and across phases. They form links and co-evolutionary chains, which may underpin VC evolution within specific phases or cause the transition from one phase to the next. They also could reflect links with other sectors of the economy. Their identification could contribute to the analysis of ‘causes’ of a particular profile of VC evolution. For this reason and following Nelson (1994) who analyzed the co-evolution between an industry and the institutions supporting it, an analysis of co-evolutionary processes should be part of the ILC framework of analysis. The development of high tech is linked and might co-evolve with the development of those financial institutions, which invest in it or perform other financial services to the industry. Moreover, the US’s and Israel’s experience clearly shows that a VC industry does not arise in a vacuum, that-for both ‘supply’ and ‘demand’ reasons- a certain level of high tech activity, high tech sophistication and other favorable conditions (such as a continued stream of new

technological and business opportunities and the creation of a critical mass of startups) are required prior to VC emergence.

Our co-evolutionary analysis in this paper focuses on VC-SU co-evolution where there are several ‘chains’ of relevant interactions: traditional supply-demand interactions, interactive learning and strong user-producer links; and wider indirect influences linked to high tech cluster re-configuration. Our focus on SU is justified for a number of reasons related to the constraints or limitations of incumbent companies in undertaking major or radical innovation (see Chesbrough 1999; Gompers and Lerner, 1999). This means that effective exploitation of the new technological/business opportunities opened up by the ICT revolution requires large numbers of high quality startups. There are several ‘sources’ of SU. In both the U.S. and Israel, many were spun-off from incumbent companies (Carmell & de Fontenay, 2004; Saxenian, 1998). Despite the undoubted contribution of startups founded by returning nationals, recent graduates from Universities and spin offs from national laboratories, prior experience in a sophisticated domestic company (or MNEs in Israel’s case) has been the source of important management and technological skills for new startups (Stuart & Sorenson, 2003). This has been pointed out in Klepper (2001) and in Gompers et al. (2003) where the term ‘entrepreneurial spawning’ was coined. Established companies have also been an important source of founders, managers and capabilities for new VC entrants¹⁰.

Supply-Demand Interactions

In Israel the starting point of VC-SU co-evolution can be found in the early 1980s when new opportunities (e.g. in Software) induced the foundation of a group of startups and emergence of new startup business models. These were linked to new forms of finance including specific Limited Partnerships for the finance of a single R&D project involving the OCS and foreign investors; the financing of high tech by Investment Banks; and the first formal VC-- Atena (created in 1985). A more dynamic process of startups creation began in the early 90s fueled by the ongoing technological revolution, by the globalization of capital markets for technology companies, and by the growth of the NASDAQ index after 1993. We estimated that by 1993 more than 300 startups were already operating in the country. Thus prior to Yozma and the VC emergence, an excess demand for VC services arose. However, this excess demand and the other

¹⁰ Examples are Matty Karp, the General Partner of Concord, a Yozma VC fund founded in 1993, who worked many years in Elbit; and Eddi Shalev- the General Partner of Genesis who had previously worked in IBM-Israel.

background conditions probably couldn't by themselves trigger VC supply without the help of a program like Yozma i.e. market or system failures prevented the un-aided emergence of a domestic VC industry. These included lack, during the early 1990s, of market-tested VC/SU reputation and critical mass that would enable partnering with foreign VCs (a critical factor in the success of Yozma); and coordination problems between startups, VC organizations and risk capital (see Gilson, 2003). Yozma program and Yozma funds, which rapidly began operating (together with some other early entrants to what later became the domestic VC industry) assured a highly dynamic response to the excess demand generated during the pre-emergence period. This led to extraordinary profits and high expectations, which stimulated VC entry and expansion. This 'excess supply' was directed first to existing startups and then to a new wave of startups, which expressed the entrepreneurial response to the enlarged set of VCs. This can be illustrated by the figures on startups creation and VC-backed startups in Table 5. The figures for the years 1990-1992 reflect the excess demand for VC financing (only 20% of startups created were financed by VC) prior to Yozma, the figures for the years 1993-1994 reflect the impact of implementation of the Yozma Program and the sudden increased availability of VC (more than 70% of startups created were financed by VCs) and the figure for the years 1995-2000 reflect the balancing of the VC-SU co-evolution (around 50% of the startups created were financed by VCs).

Finally, during late emergence VC foundations/expansion was fueled by existing and expected startups; and vice-versa- the foundation of new startups was a response not only to currently available VC services but also to future expected VC availability. In this sub-phase, we find an increasingly synchronous increase in VCs and in startups, fueled by increasingly mutually consistent expectations

Interactive Learning and Creation of Strong User-Producer Links

In young markets users (producers) learn from producers (users)-a phenomenon called *interactive learning* (Lundvall 1985). The term *collective learning* includes interactive learning and the mutual learning within the set of producers and users. The reason why interactive learning is relevant for the dynamics of VC emergence is that it involved creation of a new industry *and* of a new market.

Collective and interactive learning represent one component in the process of creation of user producer links—a widespread phenomenon in clusters (both high tech and non-high tech) and also very relevant for VC. The literature has indicated that these

links generate networks. In the VC industry, these networks enable VCs to have access to deal flow and startups to have access to a wide variety of ‘added value services’. The high impact of these links and networks is also related to other events and processes such as: startup entrepreneurs becoming VC partners¹¹; VC strategic investors becoming startups investors; VCs sponsoring potential entrepreneurs or directly incubating new startups (RAD group, Jerusalem Global), and VC partners becoming directly involved in startups foundation e.g. Star-Breezecom, BRM-Backweb, etc.

Wider Indirect Influences

Up to now we mostly considered ‘direct’ effects of VCs on startups and vice versa. There are also indirect effects which involve the wider high tech cluster and in particular the processes leading to its re-configuration. Thus the ‘*cluster effects*’ mentioned in Box 8 above would enhance the efficiency and performance of startups and thereby also indirectly affect the growth of VC. Similarly with the *reputation effects* (resulting from early very successful exits), which would both enhance foreign resources invested in Israeli VCs and the possibility that startups would gain access to global product markets. Several if not most of the sub-processes causing cumulativeness also positively affect VC-SU co-evolution although some of them could weaken it by creating other sources of ‘services’ to domestic startups. An example could be the establishment of foreign investment banks in Israel starting in 1992, which reduced startups dependence on *domestic VC*.

3.5 VC Crisis & Restructuring and Illustration from Israel

The restructuring is a response to the overshooting caused by the momentum of the VC-SU co-evolution process. Restructuring will occur at two levels- the individual organization level and industry level. At the individual organization level the possibilities are a better defined and more explicit VC strategy based on distinctive capabilities in part generated by the crisis; changed routines and patterns of VC investment; exiting of less capable startups and VCs; mergers among startups with overlapping and duplicate activities; etc¹². At the VC industry and high tech cluster

11 The classical examples are Kenneth Olsen and Harlan Andersen, founders of Digital Equipment Corporation, who later became venture capitalists (G. Bylinsky 1976, pp.6, 82, 90-1). This set one pattern of SU-VC links.

12 These have occurred in Israel. For example in response to the crises the first Yozma Fund, Gemini, has focused even more on early stage and on specific technological areas. This is reflected in its structure of capabilities. Thus all new partners and employees have a strong technological orientation; and later stage investments are now undertaken

level as regards internal restructuring we expect to find sharp decreases in the number of active VCs and startups, in VC capital raised and invested; in startups valuation; an increase in syndication and other cooperative arrangements among firms in the industry; and the elimination of low quality VC organizations, while strengthening of other high tech agents and creating more diversity within the PE industry.

During the 2001-2003 crisis the Israeli VC industry and high tech cluster were characterized by all of these processes (see table 5). There was a 66% reduction in the capital raised in Israeli VC industry during 2001 and additional 96% reduction in 2002 (before cancellation of commitments raised during the year 2000). Although VC investments were also significantly reduced (a 39% reduction in 2001, a 43% reduction in 2002 and an additional 11% reduction in 2003) they were never under the levels of 1999. The aggregate number of PE (LP VC) companies investing in startups dropped from a peak of 216 (68) to 186 (56) towards the end of 2003. Between March 2001-September 2004 there was no IPO in NASDAQ of Israeli startup companies. We also observe a sharp decline in the share of total VC investment in 'seed phase' (from 10% of total in 2000 to 5% in 2001, 2% in 2002) and a movement towards later stage financing. In addition, we observe a sharp increase in syndication and in the number of VCs who do not invest at all. Finally, we observe exit of non-professional angels and latecomers in the VC industry; and the closing of Israeli offices of foreign investment banks. On the other hand, we observe the beginning of a pattern of long-term relationships between top tier Israeli VCs & world-class foreign financial institutions and an increase in the share of foreign VCs investment in Israeli startups. This includes the setting up of offices by a few leading U.S. VCs (Benchmark in 2001, Sequoia in 2001, Excell in 2002, and Kleiner Perkins in 2004), and of some new foreign Corporate VCs with local representative office (Applied Materials ventures and Siemens ventures in 2001, Nokia VP in 2002). In general, the share of foreign investment Israeli startups remained between 50%-60% of all VC investment in Israel since 1999 (see table 5).

In the end of 2003 and early 2004 we observe first signs of the recovery from the crisis and the beginning of the consolidation process in Israel's VC industry. This is reflected by: the amount raised by the Israeli VC industry - \$724M in 2004 and \$1,052M in 2005, which is more than each year prior to 1999); and VC investments in Israeli startups grew from an average \$1,075M in 2002-3 to an average of \$1400M in

only in syndication with a lead foreign investor who can complement Gemini in the financial aspects and in capital markets' networking (interview with Orna Barry and Avi Hason from Gemini, July 2003).

2004-5. The number of Israeli startups that were acquired by MNCs increased during 2003-2005 (back to the levels of 1998-1999). In 2004, there were 7 IPOs of Israeli startups, 15 significant acquisitions of Israeli startups, and many additional many minor acquisitions; and in 2005, there were 15 IPOs of Israeli startups, and 16 significant acquisitions of Israeli startups. From the revenues side, the picture is also very positive. The total revenues and capital gains of Israeli startup firms were \$3.3 billion and \$4.2 billion, in 2003 and 2004 respectively (CBS 2005). Moreover, 297 startup were created in 2003 (back to the pace of 1998) and in 2004 the number grew to 406. In 2003 and 2004 the number of startup closures were below the number of startup creation after two years (2001-2002) in which there were more closures than startup creation.

However, at the same time we see some qualitative changes such as the growth of the non-VC agents in the PE industry - in 2004 the entire PE industry raised \$1,354M while the VC segment was responsible only for \$724M, while during the 1990's the VC segment represented approximately 90% of the PE industry. In addition, new strategic groups within the VC segment were created and new patterns of operation have been introduced. Moreover, starting in 2001 the technological incubators in the country began a process of privatization and specialization. Moreover, there is growing attention to life science sectors of VC and other PE investors.

4. Conclusions

The major contributions of the paper are three: an extended Industry Life Cycle perspective which both avoids the left truncation bias of standard industry life cycle models and is applicable to the study of VC evolution; an analytical focus on emergence or non emergence of VC, where the entity that emerges (a new industry and/or a new market) represents a higher level of organization with distinctive properties; and viewing the creation of a new industry as a cumulative, autocatalytic process with a distinctive profile of emergence.

We overcame the left truncation bias of standard industry life cycle models by proposing an extended, five-phase ILC model with two phases preceding the phase of industry emergence. The differences between the Background Conditions phase and the Pre-emergence phase on the one hand and between the Pre-emergence and Emergence phase on the other are sufficiently clear both theoretically and in terms of the empirical counterparts of theoretical variables to enable a relatively smooth application to the study of VC industries. While pre-emergence involves a continuation of quantitative

developments originating in the previous background phase other distinctive, qualitative changes signal the beginning of this second ILC phase. These include the appearance of the startup business model, new VC-related mechanisms for startups finance (in Israel, the first formal VCs as well as entry of investment banks, investment companies, holding companies and individuals); and appearance of new high tech sectors (In Israel, Software) and sub-sectors (In Israel, Data Security and Communication related IC Design) which subsequently become important during emergence. Such qualitative changes seem to have been ignored in the ILC literature even that considering background conditions (Utterback & Suarez, 1993, Utterback, 1994). Moreover it is not clear in that literature what the approximate point of transition is between the phase preceding emergence and the emergence phase. In our model the point of transition is clearly defined by ‘selection/reproduction’ of a group of architectural variables (Henderson & Clark, 1990). These include the LP VC organizational form (between 1991 and 1993 the number rose from 2 to 11), early growth of IPOs in NASDAQ (1 in 1990, 4 in 1991, 9 in 1992 and 11 in 1993) and first IPOs of very young (up to 3 years) Israeli startups in NASDAQ (Magic and Lannet in 1991, and LanOptics, Sapiens and Edusoft in 1992).

Within our framework the emergence or non-emergence of a new VC industry and/or market depends crucially on a set of pre-emergence, ILC phase 2, conditions. Examples from this paper are the demand for VC services as reflected in the pool of startups already operating prior to emergence, a process of liberalization and deregulation involving capital markets and foreign exchange, and a sufficiently strong process of variation and selection related to the organization & strategy of both startups and VCs (undertaken by agents operating in the proto-VC industry/market). Other work on industry emergence or work on new industries has emphasized additional Phase 2 conditions, which could enhance the likelihood of industry emergence. Among these and depending on industry and context we have: high capability early entrances and proto-industry agents (we have termed this Class A market forces, Avnimelech & Teubal 2004c); a policy process and Government policy capabilities which lead to the successful identification of a new set of relevant and appropriate strategic priorities (Avnimelech & Teubal 2005); and political legitimation required e.g. for a new regulatory and institutional environment (Jacobsson, 2005). The framework can also be applied to explain non-emergence and the frequent failure of VC-directed policies. For example, the failure of the German VC industry to emerge in the first half of the 1980s

(Becker & Hellmann, 2002; Fiedler & Hellmann, 2001) could be attributed to the first of the pre-emergence conditions mentioned above and to other factors. A deeper understanding of the typical pre-emergence conditions required for VC and of the processes leading to them could have induced policy makers to abstain from targeting VC directly and focus instead on policies to create favorable pre-emergence conditions (creation of a pool of startups in the German case).

The focus on industry emergence calls for an appropriate definition of the entity that emerges - 'an industry' and/or 'a market'. Since the 'emergent properties' do not refer to individual agents but to the higher level of organization. A new industry is more than a simple agglomeration of firms. In our view a new industry/market should facilitate specialization and division of labor; and through these knowledge based economic growth. It would involve greater stability than that of a simple agglomeration of firms (or in the case of a market, assurance of the possibility of repeated transactions) and-at least for a time after emergence- an endogenous dynamic reflected e.g. in new firm entry and the improvement, adaptation and diffusion of the underlying new product class or technology. VC, when it co-evolves with high tech, is one such industry/market, which emerged in Israel during 1993-2000. By facilitating the creation of a specialized startup segment of high tech (specializing in 'invention' and 'technological development') it contributed significantly both to the new high tech cluster and to overall economic growth. The state of emergence of the new industry might have happened during 1996-1998 when most VC created during 1993-1995 have raised their second fund, the number of domestic LP VC management companies doubled; and when the number of foreign VCs which got established in Israel rose to from 0 to 8 (foreign VC's decision to open offices in Israel came after a domestic industry with whom they could partner/co-invest already existed). Another indicator is M&A activity related to VC-backed startups: these would rise sharply once a VC industry is well established (the numbers rose from 2 in 1994 to 16 in 1998 – from 20% of all exits in 1994 to 59% in 1998).

Related to the above is another emphasis of this paper namely viewing industry emergence as a self-sustained cumulative process the characteristics of which are central for defining an industry and context specific *profile of emergence*. Such a profile combines background conditions & pre-emergence requirements, what sparked cumulativeness, sub-processes operating during emergence (including their timing and sequence), and the structure of the emerging industry. While additional research is

called for, Israel's VC profile would include the following conditions, events and processes: (1) Existence of favorable background conditions (1970-85) particularly the significant diffusion of R&D and innovation capabilities throughout the business sector, and creation of (an Electronics and Defense dominated) high tech industry and cluster; (2) A pre-emergence period (1985-92) during which, among other things, wide experimentation with startups, VCs and with policy took place, and where a critical mass of startups was generated; (3) VC emergence which led to a significant re-configuration of Israel's high tech cluster towards an entrepreneurial ICT-Oriented Cluster; (4) A policy-led VC emergence process spearheaded by a Targeted, VC-directed Policy (Yozma) which triggered a rapid autocatalytic process of cumulative growth during 1993-2000; (5) VC emergence being the outcome of at least eight distinct dynamic sub-processes (see Box 8) which began operating at different points of time; (6) VC emergence refers both to a new industry and a new market; (7) the resulting VC industry focused on private, independent VC companies mostly organized as Limited Partnerships and strongly focused on early phase investments in high tech (ICT) startup companies; (8) a strong process of VC-SU co-evolution which became increasingly synchronous through time and which seemed to be closely linked to the rapid reconfiguration and expansion of Israel's high tech cluster; (9) Creation of strong Global Capital Market Links (IPOs & M&A) particularly with NASDAQ; and a growing presence of MNCs in Israel; (10) Overshooting towards the end of the decade; (11) Increasing foreign investors' share in the Israeli VC market (between 40-60%) especially during the last 8 years (1997-2004); and (12) stabilization on annual investment rate of \$1-1.5B during 2002-2005; and about 40-50 active VC funds (5-10 large ones—managing more than \$200M in each fund; 10-15 mid funds—managing between \$80M to \$150M; and 20-30 small specialized funds—managing between \$20M-\$50M in each fund) and 30%-40% early stage investments.

VC industries in other countries and different industries may have different profiles of emergence. Identifying typical profiles of emergence may rank high in a future research agenda oriented to understand the emergence or non-emergence of VC and of other industries in different contexts. It will also contribute to understand the impact or lack of impact of VC policies; and underpin a renewed view of the promotion of infant industries.

Needless to say, our analysis is not a final one, but it does go beyond the state of the art. The paper's contribution goes beyond having a larger number of phases than the

standard model and beyond getting different results from those obtained when applying a different model to the same empirical setting. This because the issues analyzed include some, which cannot be analyzed within the standard ILC model. For example, the standard model cannot underpin an analysis of the timing of VC emergence in Israel nor could it suggest why such timing was important for its high economic impact. Neither can it underpin a comparative, cross-country analysis of emergence or non-emergence of an industry. These weaknesses considerably limit the usefulness of the standard theory for policy purposes

It could be claimed that, due to missing data and absence of a formal model, there is no basis for a general level claim on the whole model. This is consistent with our awareness that there exists a gap in our knowledge and in our representation of the cumulative process of venture capital emergence in Israel. Still, while we do not yet have a testable model of this process, we believe that we have successfully framed an approach to cumulative VC growth including a particular decomposition of related sub-processes, which is both realistic and amenable to further specification, refinement and eventual modeling. Moreover due to the complexities of the process, it is our view that a too early focus on modeling risks missing some essential component or sub process. Related to this is the issue concerning the methodology underlying this paper and whether or not the existing information and analysis on emergence is sufficiently interesting and useful as it is-both directly and as an inducement to additional work in the field.

References

- Abernathy, J. and M. Utterback (1978): "Patterns of Industrial Innovation", **Technology Review**, June-July, 40-7.
- Aldrich, H. (1999), **Evolving Organizations**, SAGE Publications.
- Avnimelech, G. and M. Teubal (2004a): "Venture Capital – Startup Co-evolution and the Emergence and Development of Israel's New High Tech Cluster", **Economics of Innovation and New Technology**, 13 (1), pp 33-60.
- Avnimelech, G. and M. Teubal (2004b): "Venture Capital Policy in Israel: A Comparative Analysis & Lessons for Other Countries", in Sunil, M. and Bartzokas, A. (ed) **Financial System, Corporate Investment in Innovation and Venture Capital**, Edward Elger.
- Avnimelech, G and M. Teubal (2004c): "Strength of Market Forces and the Successful Emergence of Israel's Venture Capital Industry: Insights from a Policy-Led Case of Structural Change", **Revue Economique** (special issue), 55 (6), November, pp. 1265-1300.
- Avnimelech, G. and M. Teubal (2004d): "The Indian Software Industry From An Israeli Perspective: A System/Evolutionary and Policy View", Chapter in "**The Context of Innovation in India: the case of the IT industry**", Palgrave, London.
- Avnimelech, G. and M. Teubal (2005): "Evolutionary Innovation and High Tech Policies: What can we learn from the Israel's targeting of Venture Capital?", **Science, Technology and Economy Program (STE) WP-25-2005**, Neaman Institute, Technion-Israel Institute of Technology.
- Avnimelech, G., Kenney, M. and M. Teubal, (2005): "The Life Cycle Model for the Creation of National Venture Capital Industries: The US and Israeli Experiences" to be published in Giuliani, E.; R. Rabellotti; M.P. van Dijk: **Clusters Facing Competition: The Importance of External Linkages**. *Ashgate*, forthcoming
- Avnimelech, G., Schwartz, D. and M Teubal (2006), "An Evolutionary Model of Entrepreneurial High Tech Cluster Development", Karlsson, C. (eds.) **Handbook of Research on Clusters: Theories, Policies and Case Studies**, Edward Elgar, Cheltenham, UK.
- Barry, C. (1990): "The Role of Venture Capital in the Creation of Public Companies", **Journal of Financial Economics**, 27, pp. 447-471.
- Bar-Yam, Y. (1997), **Dynamics of Complex Systems**, Perseus Books: Reading, Massachusetts, USA
- Becker, R. and T. Hellmann, (2002): "The genesis of Venture Capital: Lessons from the German experience", **Working Paper, Stanford University**.
- Black, B and R. Gilson (1998): "Venture Capital and the Structure of Capital Markets: Banks versus Stock Markets", 47 **Journal of Financial Economics**, pp. 243-277.
- Bottazzi, L., da Rin M. and T. Hellmann (2004): "The Changing Face of the European Venture Capital Industry: Facts and Analysis", **the Journal of Private Equity** 7 (2), pp. 26-53.
- Brav, A. and P. Gompers 1997, "Myth or Reality? The Long Run Underperformance of Initial Public Offerings: Evidence from Venture and Non-Venture Capital-Backed Companies", **The Journal of Finance**, 52 (4), pp 1791-1821.
- Bresnahan, T. and A. Gambardella (eds) 2004: **Building High Tech Clusters: Silicon Valley and Beyond**, Cambridge University Press.
- Bresnahan, T., Gambardella, A. and A. Saxenian (2001): "Old Economy inputs for New Economy outputs: Cluster Formation in the New Silicon Valleys", **Industrial Corporate Change**, 10 (4), pp. 835-860.
- Bylinsky, G (1976): **The Innovation Millionaires: How They Succeed**, Charles Scribner's Sons, New York.
- Carmell, A. and C. de Fontenay (2004): "Israel's Silicon Wadi" in Bresnahan and Gambardella (eds) **Building High Tech Clusters: Silicon Valley and Beyond**, Cambridge University Press, June
- Carpenter, R.E. and B.C. Petersen (2002), "Imperfect Capital Markets, High-Tech Investment, and New Equity Financing" **The Journal of Economics** 122 (477), pp. F54-F72.
- CBS (2005), **Central Bureau of Statistics**, Press Releases 67/2005, Israel.
- Dubocage, E. and D. Rivaud-Danse (2002): "The organization of exchanges on the venture capital market: Empirical evidence and theoretical issues" in Harvey, M., Rivaud-Danset G., Coriat, B. and S. Metcalfe (eds.), **Rules and the Institution of Exchange**, Manchester University Press.
- Feldman, M.P. (2001), "The Entrepreneurial Event Revisited: An Examination of New Firm Formation in the Regional Context." **Industrial and Corporate Change** 10, pp. 861-891.
- Fiedler, M.; and T. Hellmann 2001: "Against All Odds: The Late but Rapid Development of the German Venture Capital Industry", **Journal of Private Equity** 4 (4), pp. 31-45.

- Florida, R. and Kenney, M. (1988b): *Venture capital-financing innovation and Technological Change in the U.S.*, **Research Policy**, 17, pp. 119-137.
- Florida, R. and M. Kenney (1988a): "Venture Capital, High Technology and Regional Development", **Regional Studies**, 22(1), pp. 33-48
- Fornhal, D and M. Menzel (2004): "Co-Development of Firm Foundings and Regional Clusters", **Universität Hannover**, Wirtschaftswissenschaftliche Fakultät.
- Foster, J.; and J.S. Metcalfe 2001, "Modern Evolutionary Economic Perspectives: an Overview", Chapter 1 in Foster, J.; and J.S. Metcalfe (eds) **Frontiers of Evolutionary Economics: Competition, Self-Organization and Innovation Policy**, Edward Elgar:Cheltenham, UK.
- Freeman, C. and C. Perez (1988): "Structural crises of adjustment, business cycles and investment behavior", in Dosi, G. et al. (eds.) **Technical Change and Economic Theory**, Pinter Publishers, London, 1988.
- Gilson, R. (2003): "Engineering a Venture Capital Market: Lessons from the American Experience", **Stanford Law Review** Vol 55(4), 2003, April, pp. 1067-1104
- Glaser, B.G. and A.L. Strauss (1967), **Discovery of Grounded Theory: Strategies for Qualitative Research**. Hawthorne, NY: Aldine de Gruyter.
- Gomper, P. and J. Lerner (2002): "Short-Term America revisited? Boom and Bust in the Venture Capital Industry and the Impact on Innovation", *Innovation Policy and The Economy*, 3
- Gompers P. and J. Lerner (2001), "The Venture Capital Revolution", **Journal of Economic Perspectives**, 15 (2), pp.145-168.
- Gompers, P. (1994): "The Rise and Fall of Venture Capital", **Business and Economic History** 23 (2), pp. 1-26
- Gompers, P. and J. Lerner (1999). **The Venture Capital Cycle**, The MIT Press, Cambridge, Massachusetts, London, England.
- Gompers, P. and J. Lerner (1998): "What Drives Venture Capital Fund Raising", **Brooking Papers on Economic Activity** (Microeconomics), pp. 149-192.
- Gompers, P., Lerner, J. and D. Sharfstein (2003): "Entrepreneurial Spawning: Public Corporations and the Genesis of New Ventures, 1986-1999, **NBER Working Paper** No. 9816.
- Henderson, R. and K. Clark (1990): "Architectural Innovations: The Reconfiguration of existing product technologies and the failure of established firms", **Administrative Science Quarterly**, 35, pp. 9-30.
- IAEI (2006), **Israel Association of Electronics & Information Industries** (www.iaei.org.il), Israel.
- ILSI (2006), **Israel Association of Life Science Industries** (www.ilsil.org.il), Israel.
- IVC (2006), **Israel Venture Capital Research Center Database** (www.ivc-online.co.il) and IVC Yearbooks.
- Jacobssen, S. (2005): "Formation and Growth of sectoral innovation systems 'functional analysis' as a tool for policy makers in identifying policy issues", **Industrial Development Report 2005** Background Paper Series.
- Jeng, L and P. Wells (2000): "The Determinants of Venture Capital Funding: Evidence Across Countries", **Journal of Corporate Finance**, 6, pp 248-289.
- Jovanovic, B. and G. MacDonald, (1994), "The Life-Cycle of a Competitive Industry", **NBER Working Papers** No. 4441.
- Kauffman, S. (1995): **At Home in the Universe: The Search for Laws of Self-Organization and Complexity**, Oxford University Press, Oxford.
- Kenney, M. (2000): **Understanding Silicon Valley: Anatomy of an Entrepreneurial Region**, Stanford, Stanford University press
- Klepper, S. (1996): "Entry, Exit, Growth and Innovation over the Product Life Cycle", **American Economic Review** 86 (3), pp. 562-583.
- Klepper, S. (1997), "Industry Life cycles", **Industrial and corporate change** 6 (1), pp. 145-182.
- Klepper, S. (2001): "Employee Startups in High-Tech Industries," **Industrial and Corporate Change**, 10 (3), pp. 639-74.
- Klepper, S. (2002): "The capabilities of new firms and the evolution of the US automobile industry," **Industrial and Corporate Change**, 11 (4), pp. 645-666.
- Kortum S.; and J. Lerner 1998: "Strong Protection or Technological Revolution: What is behind the recent surge in patenting?", *Carnegie-Rochester series on Public Policy*, 48:247-304
- Kreps, D.M and R. Wilson (1982): "Reputation and Imperfect Information", **Journal of Economic theory** 27, pp. 253-279.

- Lerner, J. (1999): "The government as venture capitalist: The long-run effects of the SBIR program." **Journal of Business** 72 (3), pp. 285–297.
- Lerner, J. (2002): "Boom and Bust in the Venture Capital Industry and the Impact on Innovation", Federal Reserve Bank of Atlanta, Economic Review Q4, pp. 25-39.
- Malerba, F. (2005), "Innovation and the evolution of industries", **CESPRI Working Papers** 172, Centre for Research on Innovation and Internationalisation, Universita' Bocconi, Milano
- Malerba, F. and L. Orsenigo (1996): "The Dynamic and Evolution of Industries", **Industrial Corporate Change** 5 (1), pp. 51-88.
- Maskell, P. (2001), "Toward a Knowledge-Based Theory of the Geographical Cluster", **Industrial and Corporate Change**, 10 (4), pp. 921-943.
- Meggison, W. and K.A. Weiss (1991), "Venture Capitalist Certification in IPO's", **Journal of Finance**, 46 (3), pp. 879-903.
- Nelson, R (2003): "Physical and Social Technology, and Their Evolution", LEM Papers Series 2003/09, **Laboratory of Economics and Management** (LEM), Sant'Anna School of Advanced Studies, Pisa, Italy.
- Nelson, R. (1994): "The Co-evolution of Technology, Industrial Structure and Supporting Institutions", **Industrial and Corporate Change**, 3 (1), pp. 47-63.
- Nelson, R. (2004): "Evolutionary Theories of Cultural Change: An Empirical Perspective", Papers on Economics and Evolution 2004-22, **Max Planck Institute of Economics**, Evolutionary Economics Group.
- Nelson, R. and S. Winter 1982: **An Evolutionary Theory of Economic Change**, Massachusetts and London: Harvard University Press.
- Noteboom, B. 2001: "From evolution to language and learning", Chapter 3 in Foster, J.; and J.S Metcalfe (eds) **Frontiers of Evolutionary Economics: Competition, Self-Organization and Innovation Policy**, Edward Elgar: Cheltenham, UK.
- OCS (2005), **Office of Chief Science**, Ministry of Industry, Trade and Labor (www.moit.gov.il), Israel
- Odell, J. (1998): "Agents and Emergence", **Distributed Computing**, October, pp 1-4.
- OECD 1996: **Venture Capital and Innovation** OCDE/GD(96)168, Paris.
- OECD 1997: **Government Venture Capital for Technology Based Firms**, OCDE/GD(97)201, Paris
- OECD 2000: **The Internationalization of Venture Capital activity in OECD Countries: Implications for Measurement and Policy**, STI Working papers 2000/7, authored by G. Baygan and Michael Freudenberg; DSTI/DOC(2000)7, December
- OECD 2003: **Venture Capital Policy Reviews**, DSTI/DOC(2003), STI Working Paper 2003, Paris.
- OECD 2004: **Venture Capital: Trends and Policy Recommendations**, DSTI/DOC(2004) STI Working papers 2004, Paris.
- Partington, D. (2000), "Building Grounded Theories of Management Action", **British Journal of Management**, 11, pp. 91-102.
- Perez, C. (2002), **Technological revolutions and financial capital: the dynamics of bubbles and golden ages**, Cheltenham, UK: Edward Elgar.
- Rivaud-Danset D. and E. Dubocage (2004): "The organization of exchanges on the venture capital market, Empirical evidence and theoretical issues", in Metcalfe, Harvey and Rivaud-Danset (ed.) **Markets and the Organization of Exchange**, the CRIC Manchester University Press Series.
- Saxenian, A. (1998). *Regional Development: Silicon Valley and Route 128*, Harvard University Press.
- Strauss, A.L. and J. Corbin (1990), *Basics of qualitative research: grounded theory procedures and techniques*, Newbury Park, CA: Sage Publications.
- Stuart, T. and O. Sorenson (2003), "The geography of opportunity: spatial heterogeneity in founding rates and the performance of biotechnology firms", **Research policy** 32 (2), pp. 229-253/
- Teubal, M. (2002): "What is the Systems of Innovation (SI) Perspective to Innovation and Technology Policy (ITP) and how can we apply it to developing and industrialized economies?", **Journal of Evolutionary Economics**, 12, pp. 233-257.
- USPTO (2005), **United States Patent and Trademark Office** website (www.uspto.gov), US.
- Utterback, J.M. (1994), **Mastering the Dynamics of Innovation**, Boston, Harvard Business School Press.
- Utterback, J.M. and F.F. Suarez (1993), "Innovation, Competition and Industry Structure", **Research Policy** 22 (1), pp. 1-21.