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ScienceDirect
Research Policy 35 (2006) 1477–1498
research policy
www.elsevier.com/locate/respol

Creating venture capital industries that co-evolve with high tech: Insights from an extended industry life cycle perspective of the Israeli experience

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Abstract

This paper presents an industry life cycle model of venture capital (VC) and associated startup-intensive high-tech clusters based on the Israeli experience of the last 35 years. Throughout, VC is considered as a new industry, which, when successful, traverses five phases: background conditions, pre-emergence, emergence, restructuring and consolidation. Each phase comprises a number of events and processes, including policy ones. A central process is VC emergence—a cumulative, self-reinforcing process involving a number of interrelated sub-processes. A central sub-process in the Israeli case was VC-startup co-evolution, which was the critical link between the VC emergence and the transformation of the high-tech cluster into a startup-intensive configuration. Our analysis suggests that, provided appropriate background conditions prevail, VC could be central vector in the transformation of existing high-tech clusters.

Keywords: Venture capital; Startup; Industry life cycle; High-tech cluster; Emergence

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 and Lerner, 1999, p. 349). As far as the organizations involved in VC are concerned, this definition allows for two variants, a narrow one and a broad one. The narrow 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 the initial sales stage (usually between 1 and 5 years old). This is the dominant category for characterizing Israel's VC *industry*. The broad definition of VC organizations also comprises organizations that 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 and 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. 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.

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doi:10.1016/j.respol.2006.09.017

Table 1a
Capital raised by PE organization in Israel (excluding Yozma funds[a])

	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

[a] Yozma funds infused to the industry US$ 149M in 1993, US$ 40M in 1994, US$ 15M in 1995, US$ 30M in 1996 and US$ 22M in 1997.

Table 1b
Number of active PE management companies with an 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).

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 and 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—namely, NASDAQ (which was the main channel for Israeli VC exits). Israel's VC industry, which during the 1990s became one of the largest VC industries in *absolute terms* (second only to the U.S.) and the largest in *relative terms* (in terms of VC expressed as a percentage of GNP), was triggered by a government-targeted program—the Yozma program.

Tables 1a and 1b strongly suggests that the creation of the Israeli VC industry (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 Table 3) during 1991–2005 are quite interesting: during 1991–1992 VC declined by 23% annually while PE increased by 297%; during 1993–1995 VC increased by 64% annually while PE declined by 27%; during 1996–2000 VC increased by 99% annually while PE increased by 89%; in 2001–2003 VC declined by 72% annually while PE

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

[a]Our definition of 'early phase' differs from that of the OECD as summarized in Box 1. We define the seed phase as startups at the alfa (prototype) stage, usually up to 2 years old; early phase, startups at the Beta, initial sales stage, usually between 2 and 4 years old; mid phase, startups at the sales growth stage (usually between 3 and 6 years old); late, startups at the product expansion stage toward and after break-even point (usually between 5 and 10 years old and provided the startups is still 'private'). The OECD's definition would also include mid-stage in their early stage definition. *Source*: IVC (2006) and authors calculations. All the values are given in percentage.

Box 1. Distinctive features of Israel's VC industry (during the 1990s)

Highest VC investments as a share of GNP (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%)

High share of VC investments in early stages (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)

High share of VC investments in ICT and life science (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)

More than 90% of funds coming from foreign sources—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)

Negligible investments by domestic pension funds—only 0.2% of the Israeli pension funds and insurance company's assets are investments in VCs (see OECD, 2003), which contrasts with between 3 and 5% in the U.S. and Europe

A substantial share of VC entrepreneurs with S&T education and high-tech background—in contrast to EU during the 1990s where many VC/PE partners have financial rather then 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 2 funds did not have any partner with direct high-tech experience)

Exit channels—most exits are IPOs in NADSAQ (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

declined by 16%; finally in 2004–2005 VC increased by 299% annually while PE increased by 112%. To sum up, while underlying capital market trends influences both VC and PE, Yozma program, which triggered VC emergence crowd out PE activity for a while.

Table 2 clearly shows the early stages focus of the Israeli VC industry with an average of 46% investment in 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 early stage investments and in the last 4 years these investments stabilized at an average of 36% of total VC investments.

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 and 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; Carmel and de Fontenay, 2004; OECD, 2003).

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 and policy literature emphasizes capital market structure and regulation and the LP structure and contracts as the main considerations in enabling VC development (for example, Black and Gilson, 1998; Gompers and Lerner, 1998; Jeng and Wells, 2000; OECD, 1996, 1997, 2000). The exceptions include a number of studies, which are largely descriptive in nature (such as Becker and Hellmann, 2005; Bottazzi et al., 2004; Florida and Kenney, 1988; Gompers, 1994); some of theoretical work (such as Gilson, 2003); and some of our previous work (such as Avnimelech and 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 and 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 (e.g. Barry, 1990; Brav and Gompers, 1997; Kortum and Lerner, 2000; Megginson and Weiss, 1991), 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, establishing a reputation, generating networks and enhanced collective learning. Moreover, we

Table 3
Israel's high-tech cluster—selected structural elements (1969–2005)

	1969–1976	1977–1984	1985–1992	1993–2000	2001–2005[c]
Accumulated figures for a period					
Number of new high-tech firms creation	56	80	297	2,264	1,728
Israeli LP VC (PE) fundraised US$ M	0 (0)	0 (0)	170[a]	7,480 (9,495)	3,458 (6,291)
Number of IPOs at US and EU (VC-backed)	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)
	1976	1984	1992	2000	2005
Figure for an actual year					
Number of LP VC management companies (F-IB[b])	0 (0)	0 (1)	5 (2)	61 (30)	58 (32)
Share of ICT in manufacturing exports	NA	14%	28%	53%	46%
ICT exports US$ M (percentage of ICT sales)	NA	900 (51%)	2,660 (63%)	11,000 (88%)	11,100 (86%)
Software development exports US$ M	NA	5 (4%)	135 (23%)	2,600 (70%)	3,100 (81%)
R&D as percentage of GDP (OCS grants US$ M)	2.2% (20)	2.4% (97)	2.6% (199)	4.5% (440)	4.6% (263)

Sources: CBS (2006), IAEI (2006), IVC (2006) and Office of Chief Science OCS (2006).
[a] Non-official sources.
[b] F-IB means foreign investment banks.
[c] Notice that while columns 2–5 represent 8 years, column 6 represent only 5 year.

suggests that, side by side with the 'capabilities', 'strategy' and 'organization' of individual agents, it is important to know whether a VC market has or has not emerged and what its overall structure is. These are central issues in an analysis of the impact of VC on the development of high-tech clusters and on 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 (such as Porter, 2000), which seems to consider VC as one of many Marshallian 'inputs' in the cluster-formation process. In contrast to this, our analysis suggests that a central aspect of the impact of VC on the high-tech cluster is VC-SU co-evolution (see Section 3.4). Through this effect, VC has been a central axis in the emergence of the startup-intensive high-tech cluster in Israel. It also suggests that the absence of a VC-SU co-evolution may be a significant factor in the limited diffusion of the 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 and is known as appreciative (Nelson and Winter, 1982; Nelson, 2003). 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). Grounded theories are usually based on significant tacit knowledge, which has not yet been codified, written down and stored. This is central to new 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), and enabling the development of 'formal theory'.

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

Table 4
Growth of Israeli ICT and LS indicators (1970–2005)

	1970	1980	1985	1990	1995	2000	2005
ICT (and software) exports (US$ B)	NA	0.32	0.98	2.2	4.6	13.6	14.2
Life science export (US$ B)	NA	NA	NA	0.04	0.21	0.70	3.3
ICT employees (000)	NA	30.0	40.5	38.0	47.7	66.8	59.5
ICT patents	9	20	39	87	271	417	607
Life science patents	NA	5	17	47	72	215	201
Total Israeli patents	52	140	184	325	613	969	1118

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

the data with some prior hypotheses). By comparing each incident with previous incidents in the same category, the researcher develops theoretical properties of categories (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 sub-categories) 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 startups. We traced such activities along the different dimensions (phases of the model) and ascertained that through time they become more focused and eventually converged toward formal LP VCs. This process is explained by the extensive experimentation that took place in such activities.

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; (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.

1.1.1. 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 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 and chip design areas and 20 VC senior managers/partners of (mostly) leading VC companies—this represents a non-random sample but a theoretical sample that served us well when analyzing the role of Yozma funds and other early entrants on the VC emergence process. In addition, 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; on VC formation, fundraising, investment and exits; on ICT patents, sales, exports and employees; on MNE and Investment banks active in Israel; on R&D expenditures and grants. Hand-made computations where executed to identify the structure of the VC industry and to estimate the share of investments directed to 'early phase' finance and support of startups. Non-interview based data came from Israel's Venture Capital Data Center (IVC), OCS databases, Israel's Central Bureau of statistics (CBS) databases, Israel Association of Electronics and Information Industries (IAEI) databases, United States Patent and Trademark Office (USPTO) database, NASDAQ website and other sources.

1.1.2. 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. A more general application of the theoretical framework to other countries began in 2004 with a comparison to the U.S. case (see Avnimelech et al., 2005) and it is now beginning to be 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 (ILC), evolutionary economics, cluster development and VC policy 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

1.2.1. Objective 1: cast the evolution of Israel's VC industry in terms of an ILC perspective

The theoretical framework proposed in this paper for the study of Israel's VC industry is the 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 (with the first firm) and that it has traversed the full set of ILC

phases (see Abernathy and Utterback, 1978; Klepper, 1996, 1997; Malerba and Orsenigo, 1996). 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 narrow 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, 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 and Petersen, 2002; Kortum and Lerner, 2000).

1.2.2. Objective 2: further characterize the VC industry/market emergence process

The cluster development literature (e.g. Bresnahan et al., 2001; Feldman, 2001; Fornahl and Menzel, 2004; Maskell, 2001) and our previous work on the evolution of VC in Israel (Avnimelech and Teubal, 2004a,b) 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**.

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 possible influence the types of new microeconomic data to be collected. Another related issue is the notion of *Emergence State*.[2] When can we state that a new *industry/market* have been created? This question seems not to have been thoroughly discussed in the literature.[3] 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 and Utterback, 1978; Klepper, 1996, 1997; Malerba and Orsenigo, 1996; and to some extent Jovanovic and 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 Gomper and Lerner, 2002; Lerner, 2002) that represent a private infrastructure or a complementary asset (Teece, 1986) to high-tech startups. In contrast with Abernathy and 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 and Perez, 1988; Perez, 2002) and to the analysis of high-tech cluster development (Bresnahan et al., 2001; Feldman, 2001; Fornahl and 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 such as universities; institutions such as standards and arbitration; networks, interactions and links. An industry is more than one firm 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.

[2] 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)".

[3] 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.

Box 2. Phases in the evolution of the Israeli VC industry/startup-intensive cluster

Phase (sub-phase) in VC evolution	Period, Israel
Background conditions	1969–1985
Pre-emergence	1986–1992
Emergence (fluid, growth, overshooting)	1993–2000 (1993–1995, 1996–1998, 1999–2000)
Crisis and restructuring	2001–2004
Consolidation	2005–

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*.[4] For our present purposes this process, which like many other evolutionary processes involving post-selection development (Aldrich, 1999), should be characterized as self-reinforcing, 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 economics 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 (provided that external conditions do not deteriorate) in a self-reinforcing 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 Fornahl and Menzel, 2004; Saxenian, 1998).

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

2.1. Phases in the evolution of the VC industry

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

At the *background conditions phase* (phase 1, 1969–1985 in Israel) there is no startup-intensive high-tech cluster since neither a significant startup segment nor a specialized VC segment exist. Central events in this phase are the creation of a segment of R&D performing firms (a direct result of the grants to business sector R&D policy which started in 1969), and continued expansion of science, technology and higher education activities at Universities. Moreover, a number of critical events and processes pertaining to the technological and financial infrastructure for the future VC industry would take place. 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 a 'policy capabilities infrastructure' would be developed (Avnimelech and Teubal, 2006).

At the *pre-emergence* (phase 2, 1986–1992 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 be 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

Box 3. Main characteristics in the evolution of a VC industry/high-tech cluster

Background Conditions Phase	• 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. ➔ ***The startup-intensive high tech cluster does not exist yet.***
Pre-Emergence Phase	• 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 and VC–related activities; and some formal VCs. • Experimentation (variation) and Learning by SU, VCs and Policy makers. ➔ **Some important *qualitative aspects* of the future entrepreneurial cluster are getting established e.g. patterns of specialization (software and communication in Israel) and VC and SU organizational forms. Also a *quantitative* jump in the number of startups**.
Emergence Phase	• High rate of growth of VC and SU activity; large numbers of new VC and SU companies • Continuation of Experimentation by VC and SU agents → Enhanced Selection • VC-SU Co-evolution process: a Cumulative growth process caused by positive feedbacks, collective learning, scale economics and network effects. ➔ **Cumulative process of emergence of the startup-intensive high tech cluster, with a large component of *quantitative growth.*** • Entry of less skilled VC and SU agents, excessive competition and overshooting
Crisis & Restructuring	• The overshooting leads to a crisis characterized by the drying-out of the sources of capital, by a shakeout of VC and 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. ➔ **Significant changes in the structure of the startup-intensive high tech cluster, in its supporting institutions, and in its interaction with the entire cluster.**
Consolidation	• The major effect of restructuring is *sustainability* 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.

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 (in Israel for example, the 'born global' business model emerged; the LP VC organizations was identified as the most suitable design to finance and support startups, 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) followed by an accelerated *rapid growth process* (1996–1998) that eventually leads to *overshooting/bubble* (1999–2000).

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 such as a

Box 4. Evolutionary mechanisms at the startup-intensive cluster evolution in Israel

Triggers to background	• 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 (1969–1985) focus on the business sector	• *R&D-related **variation** within business sector*—experimentation with R&D/innovation projects in the business sector and experimentation in financing them by the OCS; establishment of semiconductors multinational companies 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 • ***Selection and retention***—an electronics and instruments-related high-tech sector
Pre-emergence (1986–1992) focus on the high-tech sectors and SU segment	• ***Variation** within the high-tech sector and with international links*. This primarily relates to startup creation and characteristics; to high-tech areas of activity; IPO attempts of incumbent companies and SU. Also concerning types of informal and formal VC organizations and agents. ***Selection*** of the independent, domestic VC organization • ***Selection and retention*** of the software industry and other high-tech areas; of the innovative startup model. Establishment of specific links with U.S. high-tech clusters and capital markets
Emergence (1993–2000) focus on the new cluster	• Further ***selection and retention***—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 multinational companies • ***Retention***—led to emergence of the VC industry and the new startup-intensive cluster
Restructuring (2001–2004)	• ***Selection and retention*** (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

national VC association, specialized attorneys and other startup-oriented services. This induces entry of additional domestic and of foreign VCs, rapid creation of startups and rapid growth in the acquisition activities of multinational companies. As long as external and internal conditions remain unchanged, the process of creation of large numbers of startups will continue and a startup-intensive high-tech cluster will emerge (see Table 6).

At same point of time the industry/cluster enters the *overshooting* sub-phase followed by an investment crisis. 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 (Gomper and Lerner, 2002; Lerner, 2002). The post-emergence crisis is usually triggered by, and is parallel to, a bubble. However, the post-emergence crisis actually jeopardizes industry survival; and even when the industry survives its structure may change dramatically as a consequence of this crisis (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 is characterized by very-high startups' closure-rate (see Table 6). *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 (defined by structure and strategy) within the VC industry are created and new forms of PE agents are developed (such as, e.g. corporate VCs, foreign VCs, specialized VCs, bank affiliated VCs, etc.). The industry may refocus towards later stages and fewer technological areas in-order to reduce risk (Gompers, 1994). Policy is likely to play an important role in the success-

ful 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 and the startups' closure-rate will decrease to a reasonable level (60–70%, see Table 6). This last phase will also be characterized by a relatively stable set of PE segments and the scope of their activity. Policy during the restructuring phase may have significant role in the configuration of the consolidation phase (see Avnimelech and Teubal, 2006).

2.2. Casting Israel's high-tech cluster dynamics in evolutionary terms

In order to interpret Box 4 it is important to recognize that the application of the evolutionary 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 events.[5] Israel's R&D performing firms in the business sector were the "original source" of what later became the startup-intensive high-tech cluster. 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 sector* during the first half of the 1980s, one oriented to electronics and instrumentation in general ("selection" 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 sectors and of critical characteristics of startup organization and strategy. Also, variation took place in connection with types of proto-VC agents and organizations such as angels, investment banks, affiliated and independent VC organizations, etc. This led to selection of the domestic LP VC organization as the appropriate startup finance and support mechanism.

During the *emergence* phase we observe further selection and further development of the startup segment; selection of the LP VC organization followed by reproduction leading to VC industry emergence. At this point the new *startup-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 evolutionary cycles at various levels.

2.2.1. Links to three-stage evolution

The above analysis of evolutionary processes is close to Foster and Metcalfe's *three-stage evolution* scheme based on *selection* and *development* on the one hand and *structural and qualitative change* on the other (Foster and Metcalfe, 2001, pp. 9–14). *Selection* in their context includes our variation and selection, while *development* comprises processes, which revise, add or subtract from the distinctive units of selection of the population.[6] This contrasts with the simpler, more traditional *two-stage evolution* scheme involving *selection* on the one hand and *structural change* in the other. In the two-stage evolution, the characteristics of the selection units are exogenously given and the processes of competitive selection destroy the 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 financing and supporting startup, and search/experimentation for organizational forms of VC or VC-related organizations (phases 2 and 3);
(ii) *Variation and selection are inseparably or are mutually linked*. Inseparability has been strongly emphasized by Nooteboom (2001). In our model we emphasize such links, in which selected variants may undergo subsequent variation and selection rounds. For example, an independent and domestic VC, which is 'selected' in phase 2, subsequently undergoes a process of variation concerning its specific organizational structure and strategy.
(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

[5] 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.

[6] In the three-stage evolution model qualitative and structural change are the outcomes of selection and development, with development also directly affecting selection (Foster and Metcalfe, 2001, p. 6, Fig. 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 and more complex) ones (development).

new VC industry/market. Qualitative change will include emergence of more complex forms of organization and institutions.

(iv) *A non-linear process*: in contrast to two-stage model, evolutionary mechanisms 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 3 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 sector.[7] This is necessary for a country to be able to transform 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*.

The appearance of an adequate demand for VC services during early 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' and 'external' to the economy. For Israel, 'internal' factors included the 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 startups.[8] '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 include domestic liberalization of capital markets and other institutional changes (such as adaptations of corporate law to make LPs possible, and of accountancy procedures to make them compatible with U.S. regulations). They would pave the way for a rapid phase 3 'supply response' through inflows of funds from domestic institutional 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

Venture capital in Israel became or emerged as *an* industry during the second sub-phase of the third VC ILC phase (1996–1998) The *process* of emergence during the third phase (1993–2000) 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); by 'selection/reproduction' of critical features of the industry. Table 5 shows figures on VC fundraising and investment and on startup creation and exits (IPOs and M&As). The *direct* impact of Yozma is reflected in numbers of new VC-backed startups and VC-backed exits. The indirect impact also includes the acceleration of startups formation and the general increase in startups' exits.

The number of IPOs increased considerably during 1995–2000 compared to 1991–1994; and there was an increase in the share of VC-backed issues. Both reflect the increasing maturity of Israel's high-tech industry (due to learning and other cluster effects such as the creation of the VC industry itself), although the increase in the NASDAQ index was also an important factor (note that in few or no other country did the growth in the NASDAQ index during that period induce a similar increase in

[7] 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).

[8] 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 other programs better adapted to support startups such as the Technological Incubators program were implemented. All of these programs contributed to create the VC 'demand' conditions required for a transition to phase 3.

Table 5
VC raised/invested and high-tech startups foundation, IPOs and M&As

Year	VC raised (total PE)	VC invested (percentage of 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)
1991	49 (58)	NA	51 (9)	4 (1)	0 (0)	0 (0)
1992	81 (160)	NA	85 (21)	9 (1)	0 (0)	1 (0)
1993	204 (372)	NA	117 (74)	11 (4)	0 (0)	1 (0)
1994	112 (374)	NA	132 (87)	8 (4)	1 (0)	2 (2)
1995	135 (166)	NA	165 (84)	9 (4)	2 (0)	7 (3)
1996	299 (403)	NA	218 (98)	16 (10)	3 (1)	11 (3)
1997	609 (799)	440 (43%)	248 (119)	12 (3)	0 (0)	7 (3)
1998	616 (876)	589 (44%)	308 (152)	7 (4)	6 (1)	16 (6)
1999	1,593 (1,850)	1,011 (57%)	523 (208)	12 (9)	6 (1)	15 (9)
2000	3,902 (4,644)	3,233 (59%)	615 (372)	19 (12)	13 (3)	32 (11)
2001	1,341 (1,424)	1,985 (59%)	346 (159)	2 (1)	0 (0)	8 (6)
2002	107 (217)	1,138 (58%)	326 (76)	1 (0)	0 (0)	5 (3)
2003	85 (525)	1,011 (58%)	338 (113)	0 (0)	0 (0)	9 (8)
2004	727 (1,373)	1,465 (55%)	485 (141)	6 (2)	1 (0)	15 (7)
2005	1,098 (2,752)	1,337 (51%)	340 (120)	4 (2)	11 (1)	16 (9)

Source: IVC database (2006) and authors calculations.

IPOs in that global market for technology companies). 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. Clear demonstration and reputation effects (Kreps and Wilson, 1982) are required in order to trigger multinational companies to undertake costly search for technological opportunities in a specific cluster. 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 (after 1996). 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, multinational companies start to search for technology opportunities in the cluster and this creates a strong wave of M&A.

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 emergence of the industry during 1993–2000. Government money (US$ 80M) seeded 10 hybrids funds ('Yozma funds') and an additional US$ 20M was directly managed by a government-owned fund ('Yozma venture fund'). Government's contributed leveraged an additional US$ 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

Table 6
Israeli startups entry–exit (1990–2005)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Entry	53	51	85	117	132	165	218	248	308	523	615	346	326	338	485	340
Exit	0	0	0	0	0	0	0	0	7	12	159	377	442	239	228	215

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 and technology national priorities. The outcomes were two VC directed programs—a failed precursor program (Inbal) and the successful Yozma program (implemented during 1993–1997). Yozma's design played a crucial role in explaining its superior performance since both programs had almost similar goals and their date of initiation differed by only 1 year with a 5 years overlap in implementation. Boxes 5–7 summarize the characteristics of the Yozma program and differences in design, goals and outcomes between Yozma program and Inbal program.

Box 5. Critical dimensions of Yozma program design

Promoted by the OCS and structured fund of funds (and direct investments)

Target level of capital aimed at US$ 250M (government support, US$ 100M)

Ten privately owned Israeli VC funds each managed by a local management company (formal institution) and involving reputable foreign financial institution

Government participation in each fund US$ 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 and program: privatization was completed in 1998. Yozma became a Catalytic 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 such as: (i) entry of strategic investors in response to the early reputation earned

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
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 and 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 and 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	None of the Inbal fund are among the 20 leading VCs in Israel
Very high private VC performance	Low private VC performance
Follow-up funds and 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

Box 8. Sub-processes operating during VC emergence

(1) Yozma funds and other LP VCs founded prior to 1996 *created follow-up funds*

(2) Entry of non-Yozma LP *VCs* during 1996–1998 and *follow-up funds* of these organizations

(3) Successful exits of these early entrants enhanced their reputation and eventually, the reputation of Israel's VC and high-tech industries. This led to more VC fundraising

(4) Among these we have *new strategic partners*, e.g. IBM, Cisco, Intel, Nokia, AOL, etc. as limited partners of Israeli VCs. This in turn led to further *reputation and networking* of portfolio companies, which further strengthened their activity and performance. It also led, in some cases, to *enhanced direct investments* by such partners and to enhanced reputation and networking benefiting the VC industry/ high-tech cluster as a whole

(5) During the process, foreign investment banks set up offices in Israel. This further facilitates the creation and growth of high-tech startups

(6) *Collective learning* of the VC industry and interactive learning involving both VCs and SU (see VC-SU co-evolution below)

(7) *Cluster effects* 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 is Israel, starting in 1999

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 (such as specialized lawyers, financiers, accountants and consultants); (iv) entry of multinational companies either to acquire domestic SU or for other reasons, a process which extended the cluster's networks and capabilities; (v) collective learning concerning the VC business, etc. (see Box 8).[9]

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, 1 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

[9] 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 and Teubal, 2004c).

a government insurance company ("Inbal") that guaranteed up to 70% of initial capital assets of approved VC funds traded in the Tel Aviv Stock Exchange. The program imposed certain restrictions on the investments of the VC companies covered by the program. Four funds were established without 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 nor did they 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: major points were the difficulty (relative to LPs) of publicly traded VCs to have investors contribute to the operation of the fund; idem to rapidly exploit reputation earned from early exits in order to raise new capital; limits on management decision making flexibility and on management compensation; 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 parterships 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 cumulativeness of VC emergence.

A central motivation for the operation of these sub-processes is *expected profitability* although *strategic considerations* where also important.[10] 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 profile will be characterized by a critical mass of startups which proceeded the onset of cumulativeness, 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.

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.

[10] 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.

Our co-evolutionary analysis in this paper focuses on VC-SU co-evolution where there are several chains of interactions: traditional supply–demand interactions, interactive learning and strong user–producer links; and wider indirect influences linked to high-tech cluster reconfiguration. Our focus on startups 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 startups. In both the U.S. and Israel, many were spun-off from incumbent companies (Carmel and 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 multinational companies has been the source of important management and technological skills for new startups (Stuart and Sorenson, 2003). This has been pointed out in Klepper (2001) and in Gompers et al. (2005) where the term 'entrepreneurial spawning' was coined. Established companies have also been an important source of founders, managers and capabilities for new VC entrants.[11]

3.4.1. 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 1990s 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 background conditions probably could not by themselves trigger VC supply without the help of a program like Yozma. More specifically, system failures prevented the un-aided emergence of a domestic VC industry. These included lack of market-tested VC reputation and a critical mass of VC activities 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.

3.4.2. 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

[11] Examples are Matty Karp, the general partner of Concord, a Yozma VC fund founded in 1993, who worked many years in Elbit; Eddi Shalev—the general partner of Genesis who had previously worked in IBM-Israel.

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 partners;[12] 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.

3.4.3. 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 would enhance the efficiency and performance of startups and thereby also indirectly affect the growth of VC. Similarly, the *reputation effects* (resulting from early successful exits) 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 as a channel to access foreign capital markets.

3.5. VC crisis and restructuring and illustration from Israel

Restructuring was a response to the overshooting caused by the momentum of the VC-SU co-evolution process. It occured at two levels—the individual organization level and the industry level. At the individual organization level we observed 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, etc.[13] At the VC industry and high-tech cluster 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. We also expect to see a strengthening of other high-tech agents and more diversity within the PE industry.

During the 2001–2003 crisis the Israeli VC industry and high-tech cluster went through all of these processes (see Table 5). There was a 66% reduction in the capital raised during 2001 and an additional 96% reduction in 2002. 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 beneath the levels reached in 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 and 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 the '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, non-professional angels and latecomers in the VC industry exited the industry; and several Israeli offices of foreign investment banks were closed down.

At another level we observe the beginning of a pattern of long-term relationships between top tier Israeli VCs and world-class foreign financial institutions. A major aspect of this was the setting up of domestic offices both by a few leading U.S. VCs (Benchmark in 2001, Sequoia in 2001, Excell in 2002 and Kleiner Perkins in 2004), and by some foreign corporate VCs (Applied Materials Ventures and Siemens Ventures in 2001, Nokia VP in 2002). In general, the share of foreign investments in Israeli startups remained between 50 and 60% of all VC investment in Israel since 1999 (see Table 5).

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

[13] 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 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 Gemeni, July 2003).

By the end of 2003 and early 2004 we observe the first signs of the recovery from the crisis and the beginning of the consolidation process in Israel's VC industry. This is reflected in the funds raised—US$ 724M in 2004 and US$ 1052M in 2005 (more than each year prior to 1999); and in total VC investments in Israeli startups which grew from an average US$ 1075M in 2002–2003 to an average of US$ 1400M in 2004–2005. Also the number of Israeli startups that were acquired by multinational corporations increased during 2003–2005 (back to the levels of 1998–1999). In 2004, there were 7 IPOs of Israeli startups and 15 significant and many minor acquisitions of Israeli startups; while in 2005, there were 15 IPOs of Israeli startups and 16 significant acquisitions. From the revenues side, the picture was also becoming very positive. Total revenues and capital gains of Israeli startup firms were US$ 3.3 billion and US$ 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 2 years (2001–2002) in which there were more closures than startup creation.

VC industry consolidation was also accompanied by qualitative changes such as the growth of non-VC agents in the PE industry—in 2004 the entire PE industry raised US$ 1354M while the VC segment was responsible only for US$ 724M. This constrasts with the 1990s where the VC segment represented approximately 90% of the PE industry. In addition new strategic groups emerged and new patterns of operation introduced into the VC segment; and the amounts invested in life sciences' sectors increased. It is also noteworthy that. starting in 2001 the country's technological incubators began a process of privatization and specialization.

4. Conclusions

The major contributions of the paper are three-fold: first, an extended industry life cycle perspective that avoids the left-truncation bias of standard industry life-cycle models and is applicable to the study of VC evolution; second, an analytical focus on the 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 third, viewing the creation of a new industry as a cumulative, self-reinforcing 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 startup finance (the first formal VCs); and the appearance of new high-tech sectors (software) and sub-sectors (data security and IC design), which subsequently become important elements of the new cluster. Such qualitative changes seem to have been ignored in the ILC literature, even that considering background conditions (Utterback and Suarez, 1993; Utterback, 1994). Moreover, it is not clear in that literature what is the approximate point of transition between the phase preceding emergence and the emergence phase. In our model, the point of transition is clearly defined by the 'selection/reproduction' of a group of architectural variables (Henderson and Clark, 1990). These include the LP VC organizational form (between 1991 and 1993 their number rose from 2 to 11), the 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), and significant growth in total IPOs in NASDAQ (from 1 in 1990 to 4 in 1991, 9 in 1992 and 11 in 1993).

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 de-regulation involving capital markets and foreign exchange, and a sufficiently strong process of variation and selection related to the organization and strategy of both startups and VCs (undertaken by agents operating in the proto-VC industry/market). Other work on industry emergence or on new industries has emphasized additional phase 2 conditions, which could enhance the likelihood of industry emergence. Among these, and depending on the industry and context, we have: high-capability, early entrances and proto-industry agents (we have termed these class A market forces, Avnimelech and Teubal, 2004b); and a policy process and government policy capabilities, which lead to the successful identification of a new set of relevant and appropriate strategic

priorities (Avnimelech and Teubal, 2006). 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 and Hellmann, 2005; Fiedler and 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 to focus instead on policies to create favorable pre-emergence conditions (the 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 the 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, for example, in new firm entry and in the improvement, adaptation and diffusion of the underlying new product class or technology. VC, when it co-evolves with high technology, is one such industry or market, which emerged in Israel during the period 1993–2000. By facilitating the creation of a specialized high-tech startup segment (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 the period 1996–1998 when most VC firms created during 1993–1995 raised their second funds, when the number of domestic LP VC management companies doubled, and when the number of foreign VCs that were established in Israel rose to from zero to eight (the decision of foreign VC firms to open offices in Israel came after the establishment of a domestic industry with whom they could form partnerships or syndicate). Another indicator is M&A activity related to VC-backed startups: these tend to rise sharply once a VC industry is well established (the numbers rose from 2 in 1994 to 16 in 1998 and 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 and pre-emergence requirements, the factors that 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) the existence of favorable background conditions (as in 1970–1985), particularly the significant diffusion of R&D and innovation capabilities throughout the business sector, and the creation of (an electronics and defense-dominated) high-tech industry and cluster;
(2) a pre-emergence period (1986–1992) during which, among other things, wide experimentation took place with startups, VCs and with policy, and where a critical mass of startups was generated;
(3) VC emergence which led to a significant reconfiguration 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 the period 1993–2000;
(5) VC emergence as 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 to 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 over 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 (through IPOs and M&A) particularly with NASDAQ; and a growing presence of Multinational Corporations in Israel;
(10) overshooting of VC investments towards the end of the decade;
(11) increasing share of foreign investors in the Israeli VC market (between 40 and 60%), especially during the last 8 years (1997–2004);
(12) stabilization on annual investment rate of US$ 1–1.5B during 2002–2005 and about 40–50 active VC funds (5–10 large ones, managing more than

US$ 200M in each fund; 10–15 mid-sized funds, managing between US$ 80M and US$ 150M; 20–30 small specialized funds, each managing between US$ 20M and US$ 50M); 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 industry 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 review of our views concerning the promotion of infant industries.

Needless to say, our analysis is not a final one, but it represents an advance on the current 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 is because the issues analyzed include some that 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 the 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 the absence of a formal model, there is no basis for a general level claim for 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. Nevertheless, 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 and emergence, including a particular decomposition of related sub-processes, that 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 too early a focus on modeling risks missing out 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.

Acknowledgements

This paper would not have been possible without the extremely fruitful set of comments and suggestions from the referees, and without the support and flexibility of the editors of this special issue. Their intervention has led to a significant improvement of earlier drafts. We appreciate the support received from the Venture Fun project of the PRIME Network of Excellence.

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