

Evolutionary targeting

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Abstract Evolutionary Targeting is a dynamic, systems-evolutionary policy perspective which focuses on triggering, re-enforcing and sustaining market-led evolutionary processes of emergence of *Multiagent Structures* (industries, clusters, markets, etc). A major aspect is leveraging existing successes in firms to promote emergence of such structures. This requires discrete policy interventions directed at varying areas of system/market failure, which make their appearance at difference phases of the overall process. The paper briefly illustrates the approach through an analysis of VC policies in Israel and selected European countries, and by referring to the traditional view of *Infant Industry* development and existing views on high tech cluster development. The resulting framework of analysis, which differs radically from the ‘Picking Winners’ policies of the past and from the successful targeting of infant industries in Korea and post war Japan, seems to fit the increasingly turbulent and high return/high risk global environment prevailing today.

Keywords Targeting · Evolutionary economics · Innovation and technology policy · Emergence · Infant industries · Industrial policy

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1 Introduction and background

This paper outlines a new dynamic *Systems-Evolutionary* perspective to Innovation and Technology Policy (ITP) and to policy targeting, oriented to the emergence of Venture Capital (VC) industry, other Infant Industries and other *multiagent structures*¹. The motivation is increasing recognition of the importance of (1) innovation-led and knowledge-based structural change for economic growth (Kuznets 1971; Fageberg et al. 1999; and Saviotti and Pyka 2004 among others); (2) dynamic and systemic perspectives to ITP (Edquist 1997; Teubal 1997, 2002; and Avnimelech and Teubal 2008 among others); and (3) targeting new industries (Rodrik 2004; Jacobsson et al. 2005; Avnimelech and Teubal 2005) in the context of industrializing economies. The main objective is to present a *Systems-Evolutionary* view of policy targeting of new multi-agent structures.

Based on previous comparative analyses on VC industry and high tech cluster emergence in the USA, a number of European Countries, and Israel, (Bresnahan et al. 2001, Avnimelech et al. 2005; Feldman et al. 2005; Menzel and Fornahl 2007; Teubal et al. 2007 and others), we suggest an approach to *evolutionary targeting*. This approach is based on the following notion: (1) implementation of government policy in crucial transition points of market-led development processes could have a significant influence on the effectiveness of market forces; (2) in certain circumstances a major objective of policy should be targeting the *emergence of new multiagent structures*; (3) *targeting* is often based on leveraging the success of key market agents in a particular area; (4) often market-led pre-selection and existence of some capable market forces should be considered as necessary pre-conditions for targeting; (5) in order to trigger a cumulative process of emergence, it may be important to assure a critical mass of capable market agents; (6) successful targeting should consider supply, demand and institutional background conditions and other pre-emergence factors.

1.1 Structural change, innovation and economic growth

1.1.1 Early neoclassical view

An ‘early neoclassical’ presumption is that economic growth ‘causes’ structural change. This is the result of two sets of factors: differential rates of accumulation of capital and labor that lead to an adjustment in the production structure towards a pattern which reflects the new aggregate capital/labor ratio of the economy; and changed income and price induced demand for commodities. Under this approach, there is no reverse link going from structural change to economic growth, nor does innovation play a central role in growth. Rather, growth is the outcome of capital accumulation, which in turn is the outcome of the aggregate savings/investment decision of households.

¹Multiagent structures include clusters, sectors, markets, industries, product classes and other multiagent institutions.

1.1.2 Early post-neoclassical views

Later views on the link between structural change and economic growth assign a central role to innovation and technical change. They suggest that periods of deep structural change, particularly knowledge based structural change, not only accompany but also cause rapid economic growth. An early exponent was Kuznets (1971), who introduced the concept of *Modern Economic Growth*, a process which involves, in parallel to the growth of output per capita, a high rate of change in the structure of output and a high rate of accumulation of production relevant knowledge. The latter two are interrelated and are causes of the high rate of growth of output. Kuznets' (1971) interpretation is clearly a *structural perspective*: radical innovations lead to the emergence of new sectors, which in turn propel economic growth.

Schmookler (1966) focuses on explaining the sectoral distribution of invention in terms of patterns of demand for new capital goods, i.e. gross investment. His thesis could be interpreted as involving a double, innovation mediated economic growth-structural change link: first, a link between economic growth and the sectoral pattern of investment, and second, direct and indirect links between the pattern of investment and structural change. His analysis relies on patents for which a clear link exists between patent class and economic sector. This suggests a set of links involving improvement innovations rather than radical innovations, and a changed distribution of existing economic sectors rather than more radical structural change involving emergence of new sectors.

Justman and Teubal (1991) present an analysis and survey of the *structural perspective* to economic growth and development. The authors conclude that, at nodes of structural change, the "growth process may be punctuated by periods of discrete shifts in resource allocation and growth acceleration rather than being smooth", and that "market failures may be pervasive due to problems of human capital accumulation, critical mass and discrete choice among alternative paths growth". Thus "successful growth may require an adequate industrial and technological policy, particularly at nodes of structural change".²

1.1.3 Later evolutionary perspectives

Up to the 1990s, the *Structural Perspective* did not consider a full co-evolutionary process between structural change and economic growth. This is central to the *Evolutionary Perspective*, which explicitly considers dynamic processes involving variation, selection, reproduction and diffusion of technologies, firms, structures, strategies, etc, as well as micro-meso co-evolutionary links (Nelson and Winter 1982; Saviotti 1996, 1997; Coriat and Dosi 1998; Fagerberg et al. 1999; Metcalfe et al. 2003; Fagerberg and Verspagen 2007; among others).

²The view that structural change co-evolves with economic growth also fits very well with the experience of Israel during the 1990s, during which significant structural change occurred within the high tech cluster and within the business sector. This includes emergence of a domestic VC industry, and transformation of the high tech sector into a startup-intensive high tech cluster (see Avnimelech and Teubal 2006).

One strand of structural change that leads to economic development can be analyzed in terms of two main processes: *division of labor* and *coordination*. A finer division of labor resulting from innovation could potentially, through economies of scale and learning, stimulate economic growth. This will depend, among other things, on solving the enhanced coordination problem through qualitative changes such as the emergence of new sectors, new markets and new institutions (Kauffman 1995; Metcalfe et al. 2003; Saviotti and Pyka 2004, and others). Thus, long periods of adjustment may be needed, and success may strongly depend on the presence of a virtuous co-evolutionary process between technologies, organizations, and institutions (Nelson 1994). Moreover, such process of qualitative change may also require a co-evolutionary process between the business sector, on the one hand, and government policy, on the other (Etzkowitz and Leydesdorff 2000; Avnimelech and Teubal 2008).³

1.2 The infant industry argument: a criticism

We will use the *Infant Industry Theory* (Hamilton 1791; List 1904; Mill 1909) as a benchmark for our theory of *evolutionary targeting*, despite the latter being broader in scope and relevant to a different context⁴. Infant Industry support aims at assisting new firms in less developed countries to acquire production, management, and other expertise that will enable them to compete with firms in industries that already exist in developed countries. Temporary protection of such an infant industry can be justified by the presence of one out of two possible market failures: *inefficient capital markets*, in which young firms find it hard to borrow against potential future earnings; and the existence of *positive externalities* generated by early entrants to infant industry, such as external economics of scale, and knowledge spillovers.

It is generally agreed that the notion of *market failure* and, due to ‘pervasiveness’, the *positive externalities* arguments for infant industry promotion are too general and do not provide sufficient guidance in policymaking. Moreover, whether an activity at time t generates a significant externality will depend not only on current markets, but also on their future development. Moreover, other *system failures* related to the institutional setting, market structure, and governance issues could become important in the process of industry emergence.

The large numbers of failures in infant industry promotion in industrializing economies (Bell et al. 1984) suggests that infant industry targeting is neither

³According to Saviotti and Pyka (2004, pp.1023–4) “economic development cannot be reduced to the simple growth in efficiency of existing activities, that is to purely quantitative growth... the new goods and services are often not substitutes of pre-existing ones... development is a process of transformation and not simply one of quantitative growth”. The authors present the following hypotheses: (1) growth of variety (‘the number of actors and activities in the economy’) is a necessary requirement for long-term economic development; and (2) variety growth (new sectors creation) and efficiency growth (in existing sectors) are complementary and not independent aspects of economic development. Thus, the creation of new sectors is the fundamental force that sustains economic development in the long run.

⁴Our theory will refer not only to the emergence of industries, but also to the emergence of other multiagent structures in the context of the current era of globalization and the current stage of the ICT revolution.

automatic nor assured. In its implementation to the real world, there are three major problems that the above theory does not deal with: (1) the pre-conditions for infant industry targeting (*variation* and *pre-selection*); (2) the identification and selection of those infant industries to be promoted out of a set of options (*selection*); and (3) assurance that the targeting policy will be appropriately designed and implemented i.e. lead to emergence of the new infant industry (*reproduction*). We argue that Israel's VC industry emergence process and the related *targeted* support program, i.e. Yozma program, are unique examples that could influence the design of a class of infant industry support programs as well as contribute to identifying both the required set of pre-emergence conditions of industry emergence and guidelines for *evolutionary targeting*.

1.3 New industrial policy

Rodrik (2004) focuses on structural change based economic growth and on related industrial policy. In line with Saviotti and Pyka's (2004) model, in his view economic growth can only be sustained with the continued creation of new sectors. Moreover, this process has often been stimulated by government policies. This leads Rodrik to his perspective on infant industry promotion for developing countries and on the required *new industrial policy*. First, there are clear market failures in infant industry development starting with *knowledge spillovers* from entrepreneurs, sub-optimal investment in new activities and a low rate of creation of new industries. Second, there are inherent coordination problems among new entrants to an industry for effective exploitation of economies of scale at the industry level. Both failures in the creation of new industries lead to the *new industrial policy* proposal: rather than being neutral across new and old industries and activities, policy should focus on the *support* of new industries. Rodrik also strongly advocates the development of targeting capabilities by policymakers in industrializing economies. This view strongly link with our view on *Evolutionary Targeting*.

1.4 The new global environment some implications

The current global environment suggests that a new wave of structural change and innovation-based economic growth is in the offing. During the post WWII period, a number of countries, principally in Asia, have successfully undergone catching-up processes characterized by similar features. This process is predicted to continue in the future, propelled by the acceleration of globalization and by the ongoing technological revolution.

Despite the above, it is doubtful whether a large number of countries will be capable of exploiting the new opportunities for innovation/knowledge based growth opened up by the continued process of globalization and by the ongoing technological revolutions without fundamental changes in their approach to policy and upgrading of their targeting capabilities (Rodrik 2004). This is related to the increasingly fierce competition in global markets; the fact that increasingly the opportunities for knowledge-based growth are 'high return/high risk' opportunities; and (due to enhanced system complexity) difficulty of undertaking infant industry and other multiagent structure *targeting*.

The characteristics of the current global environment also explain why *evolutionary targeting* in this paper differs from the failed ‘picking winners’ of Western economies in the post WWII period, and from the successful Japanese, Korean and Taiwan infant industry targeting during the 1960s and 1970s. The context facing those countries was less harsh than that facing present day industrializing economies, as there were fewer competitors and the possibility existed of protecting domestic markets. Today, the selection and targeting of industries is more difficult due to more uncertainty, enhanced complexity and more competition; and the process of emergence, to be successful, should proceed at a rapid pace. Thus, policies may have to assure a critical mass of resources and capabilities, which is sufficient to spark a rapid self-sustained cumulative emergence process involving significant positive feedback.

2 The system evolutionary perspective to ITP

The overarching goal of ITP is to trigger and sustain high impact cumulative processes of innovation-led growth. The strategic level of ITP deals both with identifying and setting strategic priorities and with their articulation in terms of design of new policies and programs.

This is critical particularly whenever the relevant environment (internal or external) has changed dramatically. In these situations, it is very likely that the existing policy portfolio does not match current capabilities, opportunities, needs, and threats, i.e. a new policy portfolio is required. This requires, rather than proceeding directly to design a new set of policies, initiating a policy process the first step of which is the identification of a new set of strategic priorities. Thus, while ultimately a new set of policies will emerge, they will be the outcome of a knowledge intensive process. This evolutionary view of policy would have a greater chance of leading to a new policy portfolio, which fits the new context. The outcome would be a changed policy portfolio, e.g. culling some of the existing programs, re-enforcing others, adding new programs, and combining all of these with appropriate institutional and regulatory changes.

2.1 A typology of policies

It is important to distinguish between *Incentives* and *Institutional Changes*. The former include general taxation issues, R&D grants to firms and other incentives to innovation. Institutional changes include changes in ‘the rules of the game’ such as changes in the IPR regime. Often Incentives alone might not be effective enough without complementing them with institutional changes. A third category consist of the creation of the *underpinnings* of the former two categories of policies, e.g. policy actions such as exploratory search, research and discovery directed to identify strategic priorities or policy actions directed to the creation of new policy related institutions (such as the creation of the OCS in Israel).

For our purposes, it is important to consider two general types of *incentives* programs: *horizontal* and *targeted*. Horizontal support programs are market-friendly programs supporting R&D/Innovation in the business sector without specifying an a

priori sector, technology, or product class (Teubal 1997). From a *system-evolutionary* perspective, there are three objectives to these programs: (1) promotion, generation and diffusion of business sector R&D/Innovation and associated capabilities; (2) promotion of technological entrepreneurship and entrepreneurial learning; and (3) contributions to ‘evolutionary variation’ and ‘pre-selection’ in those areas with potentially strong sustainable competitive advantage. In contrast to *horizontal* programs, *targeted* programs are focused on a particular sector or technology and their main goal is the creation of a new multiagent structure. Their specific needs are difficult to identify and their design and implementation is complex. Moreover, their impact may crucially depend on the prior accumulation of favorable background conditions, including a clear vision. We suggest that, in many circumstances during early implementation of ITPs, policymakers should emphasize *horizontal* programs while, as experience accumulates, it may be desirable to shift, at least to some extent, to *targeted* programs or at least to increase the selectivity within *horizontal* programs (Teubal 1997, Avnimelech and Teubal 2008)⁵. While in some cases promoting the emergence of new sectors may be implemented through institutional changes and indirectly through horizontal incentives programs, frequently policy targeting may also be required.

Finally, in any one particular area it may be important to distinguish between *directed* and *indirect* policies. Thus, Yozma was a VC-directed policy, while tax exemption to foreign investors or greater regulatory flexibility of pension funds should be considered an indirect policy. We suggest that often direct policy should be complemented by indirect policies in order to be effective.

2.2 An important policy objective: triggering emergence of multiagent structures

Multiagent structures include clusters, sectors, markets, industries, product classes, and other multiagent institutions. They are the substance of structural change and of innovation/knowledge-based economic growth. Frequently, new multiagent structures result from a process of emergence, which is a cumulative process with positive feedback involving externalities-generating and externalities-benefiting processes. Often the shift in emphasis from promoting individual agents to promoting multiagent structures also involves a shift from horizontal to targeted programs. Thus an early, horizontal program would focus on stimulating functions like business sector R&D of individual firms rather than stimulating a specific multiagent structure. As experience accumulates, not only in terms of innovation capabilities in the business sector, but also about areas with potential sustainable competitive advantage, opportunities will arise for greater selectivity in the promotion of firms and the targeting of multiagent structures. We argue that designing and implementing targeted programs on a continued basis requires policy capabilities and actions which are not common during the early policy phase where horizontal programs are the dominant form of support.

A new industry is more than a set of firms supplying a new class of products/services. Rather, it is a *social institution* oriented towards the supply of new

⁵Yozma is a case of a successful targeted program, which followed 24 years horizontal grants to business sector R&D programs.

products/services. It involves a certain definition of the product/service class, a critical mass of firms; supporting institutions; infrastructures; and interactions (e.g. among firms, and between firms and customers, suppliers and supporting institutions). An industry embodies what can be termed *sustainable variety*, i.e. a relatively stable product/service class that is sustainable at least during a non-insignificant period. Another characterization of many industries is the existence of *scale effects* at the industry level. From all of this it is clear that we cannot identify an established industry with the first firm supplying the relevant product/service class.

We suggest that a new industry will come into being, often, as a result of a cumulative process of emergence with self-reinforcing positive feedbacks. We also suggest that, in the promotion of infant industries, rather than searching for positive externalities policymakers should focus on cumulative emergence processes, which both generate and benefit from externalities. Thus, a major element in the transition to industry emergence is the creation of a critical mass of resources, skills, and activities that could trigger a cumulative process with strong momentum.⁶

Prior to industry emergence, the level of interconnections, spillovers, and collective learning among different market agents is quite low. In order to progress toward emergence, some coordination between market-agent activities should be created. This creates a paradox: on the one hand, there is a need for collective action (to solve the coordination issues); on the other hand, the industry is still too young to act collectively. In some cases, some agents will become market leaders in a number of dimensions, and this will determine the particular trajectory of development. But in most cases, coordination issues should be addressed directly by public agents, in ordered to be solved.

2.3 ITP in Israel

As mentioned above, triggering and sustaining multiagent structure emergence, contains a number of distinctive processes. We illustrate these processes by considering the development of the Israeli high tech cluster between the creation of the Office of the Chief Scientist and the horizontal R&D grant program in 1969, and the end of the cluster emergence process in the year 2000. These processes included: (1) development of innovation capabilities in the business sector, a process associated with dynamic economies of scale the materialization of which required the timely expansion of a horizontal R&D grant budget and the implementation of new programs and restructuring of existing ones; (2) a virtuous co-evolution process between Science and Technology infrastructure, on the one hand, and business sector R&D, on the other hand (a *push* and *pull* effect); (3) coordination of policies at a point of time and through time, e.g. between direct horizontal support of innovation in an early phase and the VC targeting in a later phase; and (4) a continuous process of ‘endogenization’ of business sector R&D, i.e. *embeddedness* of R&D within the business sector and a decline in the share of such activity financed by the

⁶Achieving the critical mass that triggers significant externalities is a major system failure in industry emergence (see Brazis and Krugman, 1996; Bresnahan et al., 2001). Thus during early emergence, a narrow technological and strategic focus seem to be a potential solution (see Avnimelech and Teubal 2006; Menzel and Fornahl, 2007).

government. Israel was a typical case where a *system-evolutionary* perspective to ITP took place. The outcome was a new trajectory of high tech growth during the 1990s, and the emergence of one of the most successful startup-intensive high tech clusters (Avnimelech and Teubal 2006).

2.3.1 Targeting VC in Israel

Within the Israeli ITP process, a central element was the targeting of the VC industry. Avnimelech and Teubal (2006) analyzed the development process of the Israel's VC Industry in terms of an *Industry Life Cycle* perspective comprising four phases: *Background conditions* (1969–1985); *Pre-Emergence* (1986–1992); *Emergence* (1993–2000); and *Maturity* (2001–2006). The main event in this process was the successful emergence of the VC industry and the associated rapid growth of the startup-intensive high tech cluster. It was preceded by more than 20 years of development of favorable background conditions and pre-emergence events⁷ such as diffusion of R&D and associated capabilities into Israel's business sector; emergence of a critical mass of high tech startups; and the strengthening of numerous personal, professional and business links with the leading U.S. high tech clusters⁸. The new VC industry and market, and the startup intensive high tech cluster expressed Israel's exploitation of the opportunities offered by the globalization process and the ongoing ICT revolution.

VC emergence led the transformation of Israeli high tech during the 1990s toward a 'Silicon Valley' type of high tech cluster involving a considerable number of startups and a wide variety of support structures (Avnimelech and Teubal 2004a, 2006). VC emergence, however, was not automatic: beyond the favorable set of conditions which evolved during 1969–1992, success was also the result of a successful targeted policy, i.e. the Yozma program implemented during 1993–1998.

Three central features characterize this innovative VC targeted program: an explicit government VC component that was directed to the business sector through the 'seeding' of privately owned and privately managed VC funds (the Yozma Funds); government risk sharing and other 'incentives to the upside'; and the requirement of partnering with foreign VCs. This support program contained elements aimed at overcoming both capital market imperfections and system failures related to the infant VC industry's development. The outcome was the acceleration of VC emergence.

During pre-emergence (1985–1992) a number of critical dynamic sub-processes operated which led to 'selection' or 'identification of focal points' of the future high tech cluster. Thus, through the activity of numerous market agents who undertook trial and error activities with respect to organization of VC and startup companies,

⁷Some of these events concern creating a dominant trajectory, while others include the undertaking of significant business experiments concerning VC and startups, policy learning, and a series of favorable external conditions. Some of the favorable conditions were themselves the result of government policies (see Avnimelech and Teubal 2005).

⁸Pre-emergence conditions could also be grouped into supply, demand, institutional, and cultural factors, e.g. emergence of a demand for VC services; appearance of some VC agents; liberalization of foreign exchange and capital markets; and a cultural shift toward entrepreneurship (Avnimelech and Teubal 2006).

and through government policy experimentation and learning, a consensus was arrived at as to the desirable characteristics of VC and startup companies—born global startups, which also focus on global capital and product markets; and LP VCs oriented to early phase finance and support of high tech startup (with an additional focus on software and communications technologies). At some point during early emergence (1993–1995) this led to an accelerated entry of VC companies fed by a cumulative process with positive feedback. It is then that the industry attained a size, which enabled it to sustain a large number of supporting institution and services. The strong *selection* and *reproduction* processes that operated during the emergence led both to acceleration of activity and to the reconfiguration of the high tech cluster.

3 A framework for evolutionary targeting

3.1 Leveraging class A market forces

Evolutionary Targeting is one aspect of the application of the *system-evolutionary* perspective to ITP and to innovation-led and knowledge-based economic growth. Based on market-led development processes accompanied by policy-enhancements at critical points, it involves the design and implementation of *targeted* programs the objective of which is promoting the emergence of a multiagent structure. *Evolutionary Targeting* operates by triggering and enhancing cumulative processes. The central idea behind the actual targeting is to leverage existing high quality (*Class A*) market forces for the purpose of building multiagent structures.

Evolutionary Targeting differs from the old “picking-winners” policy and from Korea’s post 1960s targeting (both of which are based on policy-led mechanisms), and from fully unprompted market-led processes. It is based on a new, market-friendly and bottom-up view of targeting industries. It operates by enhancing market-led variety and pre-selection through horizontal policies, and accelerating market-led selection and development/reproduction processes through coordination activities, targeted incentives, institutional changes, and other policies.

Evolutionary Targeting involves a number of policies and policy actions related to multiagent structures: (1) promotion of pre-emergence conditions to generate policy targeting candidates (*variation*); (2) determination of relevant criteria for socially desirable multiagent structures and *selection* of those to be targeted; (3) identification of system and market failures blocking the unaided emergence of selected multiagent structures; (4) determination of targeted policy objectives, design, timing, and implementation oriented to triggering (or reinforcing) and sustaining cumulative *emergence* processes; and (5) termination of targeted support.

The actual targeting process has an important time dimension. Some targeted multiagent structures will be attempted immediately, others after some time elapse⁹. One of the major evolutionary targeting issues is to know whether pre-emergence

⁹The importance of timing of targeted programs has been discussed and analyzed in the context of Yozma (Avnimelech and Teubal 2005). It would seem that implementation of Yozma prior to 1993 would run the risk of operating under a less favorable set of pre-emergence conditions, while implementation after 1993 would have encountered a shorter window for VC emergence and impact.

conditions are ready for the relevant multiagent structure targeting. Frequently, targeting has failed because the conditions were not favorable and policymakers did not realize their importance. *Class A* market forces should be considered as a key pre-emergence condition for multiagent structure targeting. We argue that, under the present harsh global selection environment, the existence of sophisticated and even profitable *domestic* market forces *operating prior to* the emergence of the targeted multiagent structure may actually enhance rather than diminish both the justification for implementing such policies, and the likelihood that such policies will lead to emergence. The importance of *Class A* market forces derives from the likelihood of strong correlation between private and social benefits, the materialization of which requires a critical mass of companies that, through coordination actions, collective learning, and other externality-generating activities, would stimulate a cumulative process of emergence of a new multiagent structure (Avnimelech and Teubal 2004b¹⁰). At first sight, the policy targeting of already ‘strong’ companies and multiagent structures would seem paradoxical, since it contradicts both the theory of support of infant industries—where the prior existence of capable market forces would seem to pre-empt the need for policy (Stoneman 1987; Bell et al. 1984; Krueger and Tuncer 1982) and the underpinnings of a simple market failure justification for policy. Its main justification is that, when *Class A* conditions hold, the emergence process triggered by the policy would be stronger and faster and the economic impact would be greater. On the other hand, the unaided operation of (even) *Class A* market forces might generate a cumulative process which is ‘too little and too late’. Thus within a range, an increase in the quality and scope of local market agents’ capabilities could enhance the justification and the expected impact from implementing a targeted policy (beyond this range policy would not be justified, since a high impact emergence process would occur without government intervention)¹¹.

3.2 Targeted program design: insights from Israel’s Yozma program

An analysis of Israel’s experience with Yozma suggests a number of directions for further specification of the theory of *evolutionary targeting*. The motivation for this program was the need to solve a specific problem—the post R&D commercial failure of large numbers of Israeli startups during the second half of the 1980s (including those having received R&D grants, see Avnimelech and Teubal 2004a, 2005). As mentioned, Yozma success can be ascribed to the prior existence of *Class A* market forces and other favorably domestic pre-emergence conditions, such as the existence of a critical mass of startups and accumulated R&D experience, and the existence of supportive external conditions such as global technological and capital

¹⁰This is also consistent with a number of analyses of cluster dynamics e.g. Bresnahan et al., 2001; Feldman et al., 2005, and Menzel and Fornahl, 2007.

¹¹When early entrants to an infant industry have weak capabilities the role of government could be directed to the stimulation of favorable *pre-emergence* conditions such as fostering startups, promoting innovation, and generating technological infrastructures, in addition to other ‘functional requirements’ (Jacobsson et al. 2005). The actual targeting of the multiagent structure should be withheld at least for a period of time.

markets growth. However, these are only necessary conditions; other conditions were required successful VC emergence were required. These include: (1) accessing capable and reputable foreign partners and investors; (2) a complex coordination process linking the above mentioned foreign VC agents with new domestic VC agents; (3) a common trajectory in terms of VC organizational and strategic characteristics that stimulate a critical mass; (4) assuring through exploitation of dynamic economies of scale that a cumulative process with a strong momentum will be initiated and completed within a short period of time; and (5) government signaling its determination to overcome all obstacles to VC emergence.

Our assessment is that most of the above were system failures that unaided market forces by themselves could not overcome. Moreover, through Yozma's design and other factors these failures were overcome thus paving the way for rapid development of capabilities in the VC industry, enhanced spillovers, and rapid growth of the tech cluster (Avnimelech and Teubal 2005).¹²

We now summarize and complete our argument concerning the role of Yozma. *First, Class A* Market Forces and pre-emergence conditions in the VC area were necessary but probably not sufficient for VC industry emergence—additional capabilities and other elements were also required. *Second*, these would not automatically be generated to the extent and the speed required. *Third*, either Yozma caused emergence or it accelerated what market forces would have accomplished anyway. Our assessment is that in, either case, Yozma was a successful policy with a significant impact. Due to the narrow window of opportunity, even if Yozma only accelerated emergence, its economic impact was significant, i.e. unaided market forces might have under performed compared to a Yozma-driven process¹³.

Finally, VC emergence in Israel was intimately related to the emergence of a new startup-intensive high tech cluster. More specifically, the Yozma program triggered VC emergence, which was the main vector in the Israeli high tech cluster re-configuration. This means that our analysis of Yozma transcends the VC policy area and becomes part and parcel of policies for the creation or re-configuration of high tech clusters.¹⁴

¹²Thus the necessity of partnering with reputable foreign agents was achieved both through a specific requirement for such partnering in order to attain 'Yozma Fund' status and from 'incentives to the upside' (the latter in turn was possible due to the deployment of a Government VC component of 80 million \$ which was used to seed privately owned and run Yozma Funds, with private investors having an option to purchase Government's share at 'cost' plus a small amount)

¹³Paul David (2001) has emphasized that effective policies implemented under conditions of strong 'path dependence' enjoy only a *narrow window of opportunity*, a statement which fits our view of the impact of Yozma (footnote 29, p. 24). We also believe that, if the timing is correct, as in Yozma's case, a strong policy impact could be linked with it having generated a *functionally desirable* path dependent process—emergence of the VC industry.

¹⁴The analysis also suggests a typology involving eight types of failures in policy targeting (Avnimelech and Teubal 2005): unfavourable background conditions, weak demand for VC services prior to VC emergence, insufficient business experiments, insufficient policy learning and upgrading of policy capabilities, flawed targeted policy design, flawed implementation, narrow window of opportunity for VC emergence and impact, and inadequate post emergence restructuring process.

3.3 Reflections on targeting startup-intensive high tech clusters

Bresnahan et al. (2001) summarizes the result of a comparative study of the dynamics of high tech cluster in several countries (including the ‘early’ phase of Silicon Valley, Ireland, Israel, and India. In analyzing the forces at work, the authors make a distinction between “*old economy*” forces (entrepreneurship, risk taking, R&D investment, and infrastructure building) and “*new economy*” forces (exploitation of dynamic increasing returns to scale resulting from external economies and positive feedback). Their central argument is that “*old economy*” forces were operating prior to the establishment of new high tech clusters, while “*new economy*” forces operated after cluster emergence. On the normative side, the authors seem to hold the view that targeted cluster creation’ policies are generally not desirable. More specifically, their policy conclusions are: (1) there is no basis for supporting infant clusters; (2) efforts to jump-start clusters or to make top-down efforts to stimulate entrepreneurship will fail; and (3) accommodative government policies can be an important part of cluster development¹⁵.

Our main critique of the Bresnahan et al. (2001) policy analysis is that (1) their adoption of a rather restricted dynamic framework of analysis, which emphasizes two extreme states (*nascent* and *established* clusters) without a systematic analysis of other phases and phase transitions, ignores the process of cluster emergence; (2) this restricted classification forces them to adopt a dichotomy of effects—no cumulative processes during the nascent cluster state and strong ones once the cluster has been established. We argue that, while the direct and indirect external effects and associated cumulative processes (i.e. “*new economy*” forces) are very important in *established* clusters, they are also important during the preceding *process* of cluster emergence; (3) high tech cluster emergence could be strongly linked to VC industry emergence, i.e. VC services are not simply one additional input to the cluster, but are as well a possible driver to its emergence¹⁶; (4) once sufficient background and pre-emergence conditions have been generated (including, in the Israeli case, having generated a critical mass of start ups), policy targeting may contribute to sparking of a cumulative emergence process (although like with Bresnahan et al targeting during the “*nascent cluster*” phase is not desirable); and (5) when identifying the common factors characterizing successful clusters (their sample does not include ‘failed’ clusters), they adopt what could be considered as *a list of critical factors* associated with success. While this approach is useful as a first approximation to the problem, it falls short of being a fully dynamic analysis of ‘cluster emergence’ (see e.g. Breschi and Malerba 2001).

¹⁵“Apart from public investments in areas like education, government played an important supporting (though not leading) role in making entrepreneurship easier in many regions, notably in Ireland, Taiwan, Virginia and Israel”

¹⁶Moreover, since a VC market could be a major mechanism for reducing capital market inefficiencies in potential high impact high tech clusters, there may be grounds for promoting such an industry and market early in the process.

4 Summary and conclusions

The objective of this paper is to underpin the emerging field of *Evolutionary Targeting*. The analysis is based on prior work by the authors on emergence and non-emergence of VC industries (with a particular, although not exclusive, focus on the successful Israeli case) and the conditions for the successful targeting of such industries in a wide variety of contexts (Avnimelech and Teubal 2005, 2006). It is also based on recent developments in the literature particularly in the high tech cluster dynamics (Bresnahan et al. 2001; Feldman et al. 2005; Menzel and Fornahl 2007). Finally, our theme links centrally with certain strands in the economic development literature, such as infant industry theory, the ‘functional requirements for new industries’ (Carlsson and Stankiewicz 1991, Jacobsson et al. 2005), ‘new industrial policies’ (Rodrik 2004), evolutionary economics ITP (Metcalf 1994), and ITP cycles (Avnimelech and Teubal 2005, 2008).

An important motivation was the growing realization of the importance of high impact innovation based structural change, such as the development of new industries (Saviotti and Pyka 2004 and many others) for sustainable economic growth, and increasing empirical and theoretical justification for government intervention to promote growth and structural change in developing countries (Rodrik 2004). These reflect the changing global environment, one characterized by enhanced uncertainty and competition, increasing ‘winner take all’ situations, and the difficulties in identifying new sectors/product classes for targeting.

The proposed *Evolutionary Targeting* framework recognizes the importance for innovation/knowledge-based economic growth of new *multiagent structures* such as clusters, sectors, markets, industries, and product classes. It is an explicitly systems-evolutionary framework with respect both to policy formulation and implementation and to the underlying ‘positive’ analysis and interpretation of the real world. It focuses on market-led evolutionary development processes, mostly cumulative, based on leveraging *Class A* market forces to prompt new multiagent structures. Triggering and sustaining the associated emergence processes requires discrete policy interventions directed to various system failures, which make their appearance at difference phases of the process. The paper briefly illustrates the approach through an analysis of VC policies in Israel and selected European countries. The approach also sheds light on a new perspective for targeting high tech clusters and infant industries in industrializing economies, one which seems to fit the increasingly high return/high risk global environment prevailing today.

The outcome is a view of targeting that differs radically from (1) past ‘picking winners’ policies, in that it is largely a market-led process, and (2) the previous successful infant industry targeting of Korea and Japan. Major conclusions are that targeting emergence of multiagent structures is possible, although complex, and there are numerous possible causes of policy failure (it may require adequate policy institutions and ‘generic policy targeting capabilities’ (Rodrik 2004); that a major focus is how to spark and sustain cumulative emergence processes; and that targeted policy design and timing of implementation are crucial.

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