

**A CATCHING UP INNOVATION AND
TECHNOLOGY POLICY (ITP) LIFE CYCLE
MODEL-Lessons from Israel**

*From Direct Support to Business Sector
R&D/Innovation to Targeting Venture
Capital/Private Equity*

Gil Avnimelech and Morris Teubal*

August 11, 2006

A. MOTIVATION-1

A central assumption of the paper is that the opportunities opened by the ICT revolution & by Globalization may accelerate the process of ‘catching up’ of industrializing economies.

For the first time conditions were created for emergence of *a specialized segment of ‘inventor’ companies* (high tech start ups, SU) who perform an essential function in the articulation of the new ‘generic’ technologies.

A-2

The new private and public capital markets (venture capital and NASDAQ-type stock exchanges) enabled SU entrepreneurs and inventors to obtain an ‘anticipated’ return to their investments-through the capital rather than through product markets

These markets also facilitate the transition from invention to innovation (e.g penetration of global markets) and diffusion, and thereby make an important contribution to what may be termed ‘knowledge-based growth’

Prime examples are Silicon Valley; and Israel in the 90s

A-3

- **The above high-tech trend was followed by enhanced emphasis on ‘innovative SME’s in general’, whose contribution to overall employment began to be recognized during the 1980s (e.g. Gompers 1994). Innovation may be the result of other, non-R&D processes; and be located in mid/low tech and in services**
- **A domestic venture capital (VC) industry and/or market may facilitate and accelerate such a process. In the US (and European) cases it also supported innovative SMEs not only SU**

A-4

The Israeli experience is one variant of a general Innovation Policy model that emerges with the ICT Revolution. Important roles were played *first* by massive and consistent support for BS R&D since 1969, *followed* by Venture Capital (promoted by a ‘targeted’ Government program and oriented to SU-Phase 3) which emerged as a new industry and market during the 1993-2000 period.

A-5

- **Direct support to BS R&D/innovation played *direct* and *indirect* roles in innovation. It was the mechanism which overcame market/system failures blocking emergence of BS innovation in a wide front; and it created conditions which facilitated the successful targeting of venture capital 24 years after initiation of the program.**

A-6

- **For other countries, different variants of the implicit *phases- model* of Innovation and Technology Policy (ITP) may be relevant.**
- **While the Israeli variant may have some relevance for (parts of) Russia and India given the high level scientific and engineering manpower available; and the existence of high quality institutions of higher learning and scientific research—**

A-7

---other countries may require a *Phase 1* involving both direct and indirect support of innovation. This means support both to the Science, Technology and Higher Education infrastructure (STE); and Direct support for Innovation in the business sector (not only R&D based innovation in high tech sectors!!)

A-8

Note

When VC is defined ‘strictly’ (as ‘early phase support of high tech start up companies SU)- success in the creation of new VC industries or markets *have been rare* beyond the US at least till 2000.

Israel is one example where a VC industry/market was created (during the 1990s); through a ‘targeted’ program (Yozma); which resulted in a transformation of high tech into a Silicon Valley model (*large numbers of SU and VC*)

A-8

The process in Israel led to a significant

- **deepening of R&D-GERD/GNP reached 4.3% last year**
- **Increase in BS R&D/GERD (from 20-80% in 20/30 years); and**
- **a lower share of BS R&D financed by the State.**

However, Israel's successful targeting of VC in the 1990s did not arise from thin air.

VC policy was not the initial means to promote BS R&D, high tech or high tech clusters; it came into play only after significant growth of BS R&D took place (promoted by direct means)

B. Central Analytical Idea

- **The central idea underlying ITP phases is generating a virtuous STE-I (Science, Technology, Higher Education-Innovation) co-evolutionary process. Major forces would be-**
 - $ST \rightarrow I$: a *push* effect**
 - $ST \leftarrow I$: a *pull* effect**
- **Such a process would assure a continued and rapid growth both of (BS) Innovation and in STE**

B-2

- **We assume that such a co-evolutionary process involves *dynamic economies of scale* I.e cumulative processes with positive feedback**
- **Policy-wise there are two issues:**
 - * **How to *trigger* such a process**
 - * **How to *sustain* the process**
- **This should also help identify the relevant Market/System Failure I.e which portfolio of policies to implement at each ITP phase.**

B-3

- **For historical reasons, Israel in the late 60s, early 70s had a high quality STE but little innovation (excepting in Agriculture) I.e. supply push alone had a weak effect.**
- **There were clear Market Failures (lack of incentives) blocking an endogeneous generation of BS innovation -even though the STE infrastructure was there.**
- **Government grants to BS R&D solved the problem, at least for a time. It spurred the beginning of STE-I co-evolution.**
- **This is/could be presumably the case of India and Russia today**

B-4

- In other cases with less well developed STE infrastructures, the market/system failures blocking a cumulative & sustainable STE-I process (and therefore, rapid growth of BS innovation) lied both with STE and with I
- In those countries Phase 1 would involve simultaneous building of basic ST institutions and direct promotion of BS innovation

B- 5-Potential Relevance: India

- 1. Like in Israel during the 1970s, India's strong Science, Technology and Higher Education (STE) infrastructure could underpin a strategic objective of promoting Business Sector (BS)-innovation/R&D in a wide scale (Phase 1 policies)*
- 2. Moreover, its R&D performing MNEs and high tech diaspora community would both contribute to the above and to generate conditions for a transition to Phase 3 (VC and other targeted policies—see below)*

B-6. Potential Relevance: Other LDC's

Korea has (after the 1997 crisis) switched its strategy in the direction of transforming its System of Innovation to include (side by side with large conglomerates) significant SU & VC activity

Israel's experience might be interesting both for top tier industrializing economies and for other such economies wishing to accelerate their catching up processes.

As mentioned, the process need not exclusively involve fostering high tech SU and formal R&D (like in the Israeli case): it also would involve stimulating 'innovative SMEs' more generally speaking and a broadly defined view of innovation (variants to the generic 3 phase ITP model)

B-7: Common Issues

- **When will Phase 1 policies create conditions for the successful transition to Phase 3?**
- **We will see that when VC and a new Entrepreneurial High Tech Cluster (EHTC) are the entities to be targeted in Phase 3- the (Phase 2) necessary conditions may have to include (as it was up to and including the 1990s) ‘*creation of a critical mass of SU*’ which represent ‘sufficient’ demand/deal flow for the future VC industry.**

C. SPECIFIC OBJECTIVES

- **Present a ‘generic’ 3 phase ITP (cycle) model for industrializing economies, characterize a ‘variant’ relevant to India & other variants relevant for other LDC types (ongoing work) and compare it to the Israeli model**
- **Identify Phase 2 ‘transition conditions’**

Different countries will have different profiles for Phase 2 (or alternatively, would represent different variants of the ‘generic’ three phase ITP model

Phase 2 will include widespread experimentation, also with public/private support mechanisms

We briefly consider aspects of the Chilean and Korean cases; refer to the Indian case, and compare them to the Israeli case

Issues of Governance of Innovation may be critical

D. ISRAEL'S THREE PHASE ITP MODEL-1:Background

- *Strong STE infrastructure and a commitment to sustain and develop it*
- *Significant Defense R&D, the source of many technologies applied later during the 1990s*
- *Gradual opening up and liberalizing During the 1980s*

D. ISRAEL'S 3-PHASE ITP MODEL-2: Strategic Priorities

Phase 1(1969-1984)

Diffusion of BS R&D, creation of R&D/Innovation Capabilities, promoting Technological Entrepreneurship

Phase 3 (1993-2000)

Targeting VC/PE & Accelerated growth of R&D and High Tech

There was, probably unjustifiedly, continued growth of R&D grants (peaked in 2000).

D-3

**The successful transition from Phase 1 to Phase 3 (the conditions for VC targeting to be successful) *required a number of events and policies* during the intermediate period (1985-1992)-
Phase 2**

D-4: Phase 2 (1985-1992)

The major events/developments:

- *a critical mass of SU;*
- *establishing international (especially) capital market links;*
- *liberalization of capital markets and foreign exchange; and*
- *Identifying a new intermediation form, suitable to the local context, linking VC to SU* –a precursor conditions for a new industry/market

D-5: Phase 2

Also, a number of policy actions and policies were required:

- **To support the above**
- **To effectively design and implement a targeted, VC-directed program**
- **Policy Capabilities (particularly for targeting)**

D-6: Phase 2-Government Actions and Policies

A. Direct support of BS R&D/Innovation

**Reduced effectiveness of BS R&D Grants -
→ *search for causes* → *lack of post R&D capabilities* (termed then ‘weak management’)
no less than lack of finance**

**In parallel, continuation and eventual increase in
*Business Sector R&D Grants***

**Also, *new BS support Programs* (Generic R&D-
deepening of BS R&D and linking with Unversities; Incubators-
to facilitate entrepreneurship and absortion of inmigrants)**

D-7

B. New Strategic Priorities & Identification of System Failures

BS R&D additionality, not enough any more

New ITP priority: *promotion of SU foundations and growth* ; and a new strategy: *creation of a domestic VC industry (& market)*

Identification of *System/Market Failures blocking the un-aided development of a domestic VC industry/market*

D-8: Phase 2 (Policy)

C. Policy Experimentation and Learning

Individuals and Organizations experimented and learned with respect to the organization and strategy of SU companies ('born global' strategy); idem concerning the possibility and desirability of early phase investments in SU; possibly concerning the desirability of Limited Partnerships

Some policy makers (those based on the Office of the Chief Scientist who managed the grants programs)-learned from these experiments

D-9: Phase 2 (Policy)

Policy Makers experimented and Learned → influence on critical aspects of Design

- **Search → identification of a domestic VC as a Strategic Priority; the incentives required to bring high profile foreign partners to Israel ; that Limited Partnerships worked very well in the US**
- **from Business Experiments → that it should focus on early phase finance/support of SU; how much Government venture capital should be made available (settled at 100 M\$); probably-who could create VC management teams**
- **from Inbal- → should avoid bureaucracy at all costs; critical mass of resources, the importance of Limited Partnerships as a VC organizational form appropriate to Israeli conditions.**

D-9: Phase 2 Policy and Policy Actions

D. Targeting of Venture Capital

A failed *precursor VC-directed program* (Inbal, 1992)

It influenced the design of the subsequent very successful Yozma Program-1993-1997

The effect was emergence of a new industry and market(VC); co-evolving with it-a very large number of SU; and a new high tech cluster.

D-10: VC and High Tech Cluster Data, 1990s

- *Accelerated growth of VC activity e.g. capital raised and invested; about 9- 10 B \$ under management towards the end of the 1990s*
- *About 130 high tech IPOs, mostly in NASDAQ, most of them SU*
- *Almost quadruplication of high tech exports during the 1990s, reaching 14-15 B\$ towards the end of the decade*
- *About 2500 SU foundations*

E: TOWARDS A GENERIC ITP CYCLE MODEL FOR INDUSTRIALIZING ECONOMIES-GENERAL

Focus on Innovative SMEs, including high tech SU
(depending on case)

Part of a wider strategy for Economic Development

Support of innovation broadly speaking rather than
exclusive supporting formal BS R&D (as was in
the Israeli model)

It includes innovation in mid/low tech, services and
traditional industries.

E-General

The generic three phase ITP model is ‘work in process’ focused on generating additional variants to the Israeli variant

The policies and events belonging to the various phases (especially those of Phase 2) need not belong to a single variant of the ‘generic’ model

As with the Israeli variant, underlying all variants is the objective of generating a virtuous STE<->I co-evolutionary process

E-1:STRATEGIC PRIORITIES (SP), Phase 1

- **Support of innovation (largely horizontal/neutral) and creation of innovation capabilities -also in innovative SMEs**
- **A ‘basic needs’ oriented component in the overall promotion of innovation**
- **Wide experimentation (‘variation’) about the suitability to the local context of various types of innovation, technology, organizations,etc(→ horizontal programs)→create ‘realistic’ options for future targeting.**
- **Assure existence and operation of a basic set of Science, Technology and Educational institutions; and special institutions supporting innovation e.g Fundacion Chile**

E-1: SP, Phase 1

- **Whenever relevant-*selective support* (e.g through ‘targeting’) of industries for which there already are clear Sustainable Competitive Advantages (SCA): Software in India, Copper & Salmon in Chile, organic foods in Argentina, etc**
- **Phased liberalization and opening up; and selected nurturing of international links (to be continued in Phase 2)**

E-2:Strat. Priorities, Phase 2

- *Widespread Diffusion of Innovation/Innovation Capabilities throughout the Business Sector (BS)*
- *Promotion of Innovative SMEs (to assure demand for future innovative SME service industries e.g. VC)*
- *Identification of New Intermediation Form for finance/support of Innovative SMEs (VC variant)*
- *New Innovation and Technology Policy (ITP) Capabilities*
- *Other General Conditions*

E-2: Phase 2, *Promotion of Innovative SMEs*-Action Areas

- **Strengthening of Innovative Entrepreneurship**
- **Assuring *critical mass of innovative SME's*** (maybe specific programs to this effect)
- **Promoting *Technological Infrastructure oriented to innovative SMEs*** e.g. physical, Technology Centers, generic-cooperative R&D, etc
- **A stronger *Business and Innovative SME orientation of the basic STE infrastructure***
- ***Experimentation* with different types of Innovative SME organization and strategy**

Phase 2, Identification of New Intermediation Form -Action Areas

- **Experimenting with new Equity-based, innovative SMEs finance and support mechanisms/organizations**
- **Adaptations of the institutional framework e.g. to allow US/Israeli type Limited Partnerships (e.g Finland)**

Phase 2, *New Policy Capabilities* -General

- **Creating a *'generic policy capability'* for *targeting higher organizational level entities* e.g. sectors, product classes, markets, clusters, technologies (extension of Rodrik's proposals in the direction of *'evolutionary targeting'* or *'strategic level of policy'*)**
- **Involves *setting new SP's and articulating them in terms of new policies and Programs***
- **This is a *gradual process* involving search, other investments, policy experimentation and learning, new policy institutions/mechanisms, etc**

Phase 2, *New Policy Capabilities* -Action Areas

- ***Identification* of entities (product classes, etc) with a potential Sustainable Competitive Advantage e.g VC, new “infant industries”**
- ***Pre-selecting* a subset e.g. stem cells and/or homeland security in Israel**
- ***Identifying System Failures***
- ***Design of new Targeted Programs and Policies***

Phase 2, *New Policy Capabilities-Specific* Actions/Underpinnings for new Infant Industry Promotion

- **Identify product classes where Class A firms operate, but where an ‘industry’ is not yet in existence** [Class A is one indicator of Sustainable Competitive Advantage (SCA) potential]
- **Promote Business Experiments/Learning in areas with high SCA potential** e.g concerning organization, strategy, internationalization, etc
- **Creating pre-emergence *functional/systemic* requirements** eg. Collective institutions/capabilities (F. Chile, CG &IB in India), regulatory frameworks, political legitimation

Phase 2-Other General Conditions

Cultural Changes

Interactions and Networks

- **New Agents and New Arenas of interaction**
- **Latching Policy Makers to International Networks**
- **New Policy Making Mechanisms**

Governance Issues

- **How STE & I budgets are determined?**
- **Allocation procedures, coordination among agencies, etc**

E-3: Strategic Priorities (Phase 3)

- **Creation of a globally linked VC/PE industry or market (depending on country)**
- **Implementing other targeted programs e.g. directed to new infant industries/product classes**
- **Rapid growth of the innovative SME segment and entrepreneurial clusters**
- **Enhanced share of R&D in GDP; etc**

D. More on Phase 2: *Emergence of Demand for Future VC Industry*

A critical facilitator for Phase 3 VC policies

Requires a critical mass of innovative SME's

In Israel: about 300 SU some of them of high quality were in existence by 1993 (when Yozma was implemented)

Chile in year 2000: for lack of deal flow due to insufficient numbers of innovative SMEs and SU-the VC policies failed to trigger a VC industry/market (i.e. Chile was not yet ready for Phase 3)

D: More on Phase 2-*New*

Intermediation Form

Business Experiments and Learning (Israel)

- They relate to SU and to VC
- They facilitated the subsequent design of Yozma e.g. selection of LP form of VC organization
- SU: born global strategy; and structuring to access both global product and global capital markets
- VC: VC companies (of the *proto-industry*), individuals, corporations learned about the functions and operation of formal VC organizations (raising capital, adding value to SU; certification, help launching an IPO, etc)
- Learning by Government and by business about the appropriate form of VC organization (for Israel -the Limited Partnership form, LP) & strategy

D. More on Phase 2: POLICY CAPABILITIES ‘MODELS’

- Israel, early 1990s: *Problem Solving approach* (little anticipation of problems, no ex-ante creation of search and prioritization capabilities)

-Korea, post 1997: *Systematic planning and coordination, explicit attempt at creating new organizational routines; attempts at dealing with Governance of Innovation and STE policy (supra-ministerial committee attached to the President)*

-Chile, starting mid 1990s: *critical role of Fundacion Chile, a private, non-profit institution*

D. More on Phase 2: Developing Policy Capabilities-Problem Solving in Israel-1

Policy Learning Through ‘Search’

- **Identifying why BS R&D grants had a weak impact(→ weak management and post R&D ‘complementary assets’)**
- **Finding a solution→ creation of a domestic VC industry**

Policy Learning From Failed Inbal Program

- **Disadvantages of publicly traded VCs→ importance of Limited Partnerships (LP); heavy bureaucracy in managing the program**

D. More on Phase 2.....Problem Solving in Israel-2

Facilitators or Underpinnings

The above learning was facilitated by a significant accumulation of experienced-based (operational) ITP capabilities-a result of 20 years of supporting BS R&D

Also, by success in ‘responding’ to new BS needs and opportunities (→virtuous BS-ITP co-evolutionary process)

D. More on Phase ...Problem Solving in Israel-3

Impact: A better design of Yozma

- **LP form of organization**
- **Fund of Funds: the major use of Government's venture contribution**
- **Incentives to the upside**
- **A reputable foreign partner requirement**
- **Selection of VC teams according to abilities;etc**

D: More on Phase 2..Creating ‘Strategic’ ITP Capabilities (General Aspects)-1

Strategic capabilities are critical for identifying new priorities and translating them into new programs

*The need arises with radical changes in the environment
e.g. the 1997 crisis in Korea; post-2000 in Israel*

They require explicit investments; a multidisciplinary team, new capabilities (gradual creation of new organizational routines); explicit search for new opportunities and also to anticipate future problems; and new institutions (e.g. a Strategic Technological Forum or functional equivalents). Also new procedures and methodologies (e.g. computer simulations, scenario building)

D. More on Phase 2: Creating ‘Strategic’ ITP Capabilities (General Aspects)-2

Specific Actions

- **Ascertain the feasibility and desirability of creating a VC/PE industry and market**
- **Identify other possible areas for targeting (with strong potential of Sustainable Competitive Advantage)**
- **Initiate and enable experiments; also in targeting (experimental implementation of such programs)**
- **Identify alternative mechanisms for the above**

D. More on Phase 2: Developing Policy Capabilities- The Chilean Case

Special role played by a private, non-profit institution (Fundacion Chile)

FC undertook a wide range of Business Experiments in the areas of transfer/adaptation of new technologies and creation of new sectors e.g. salmon

It also spawned out companies who implemented the new technologies/sectors

These and other mechanisms, by reducing basic uncertainties, 'gave proof' of areas with long run potential competitive advantage(→ enhanced targeting capabilities)

Illustrates potential importance of 'mixed' system of Governance for Phase 2

CONCLUSIONS 1: The ITP Cycle Concept-1

**The ITP Cycle could be an important
concept for successful catch up policies**

- **Its analytical backbone is *STE-I co-evolution*, here conceived as a cumulative evolutionary process**
- **System/Market failures may block the triggering and sustaining of the process**
- **They and the corresponding policies will change throughout the Cycle**

-2

- **Thus if a country for historical reasons has a well developed set of STE institutions (and despite this there is very little innovation-the ‘push’ process is not strong), then sparking a process may require direct support of innovation i.e there is a market failure in innovation. In other cases the system/market failuers required to spark the process may involve acting both on the STE institutions and on BS innovation simultaneously.**

-3

- **Also sustaining the process may require Government action to overcome a slow down or ‘stalling’ in the process, thus assuring ‘Phase Transitions’**
- **Countries may easily stall in Phase 2**

-4

- **a too rapid reduction in the direct support of innovation (prior to the broad development of capabilities & innovative entrepreneurship etc-see below) may block materialization of the desired transition to Phase 3**

Dynamic Links between Policies

An implication is that an ITP cycle perspective links policies through time e.g. in the Israeli variant, earlier direct support of BS R&D (Phase 1) to later support of VC (strictly defined-Phase 3). In other variants, from early support of innovation broadly defined together with basic STE support to later support for emergence of new equity based mechanisms of finance and support of innovative SMEs; and targeting of new Infant Industries

A central issue is that of Phase transitions-it is clear that the transition is not automatic nor seamless. A number of conditions must hold, some of them could be influenced by Government action.

Criticality of Phase 2-1

Crucial facilitating roles might have to be played by Governments in such a transition. We could interpret it as setting a new basis for ST-I co-evolution one that relies less on direct and massive support of innovation by the Government and more on generating new conditions in the private sector to finance and support such activity

The above is no mean task

This has not been systematically analyzed in the literature yet

-2

A major emphasis of the paper is disentangling the complexities of the intermediate Phase 2, where both direct Government action and stimulation of hybrid forms of Governance of Innovation may be crucial

Thus the Governance of Innovation in Phase 2 is a crucial topic for future work (Chile's case is one interesting example, Korea's is another)

Our dynamic analysis of direct support to BS R&D/Innovation goes beyond most of the existing literature (and maybe beyond policy practice as well)

Potential Importance of direct support of BS innovation

There are multiple objectives to the Grants to BS R&D program: diffusion of R&D capabilities; stimulation of technological entrepreneurship; and generating variation which will help identify possible areas of long term competitive advantage.

Entrepreneurs are learning; it is not clear yet who is ‘good’ and who is ‘bad’. Therefore, policy should not mimic the activity of VC i.e. grants are not equivalent to ” ‘Public VC’ (Lerner 1999)”

The objective is to create a first and very basic ‘private infrastructure’ with whom subsequent public action can interact.

Increasing Returns to Policy

A final point is that of increasing returns to policy (this is conditional on developing policy capabilities)

A successful implementation of a single program e.g. the Grants to BS R&D program of Phase 1- will lead to ‘diminishing returns’ (i.e. market failure will be compensated for)

However, from an ITP perspective, this would create new opportunities for policy e.g. for VC or other targeting. This could mean increasing returns rather than decreasing returns.

Changing Structure of Government Support/Action

It is wrong to jump stages and to assume a very rapid reduction of Government action after a successful phase 1. Rather than reducing the scope, our analysis suggests a changing structure of Government action, including systematic analysis of mixed and varied Governance structures and of business experiments.

Depending on conditions, Government intervention in the ITP area may increase or decrease (under normal conditions it must decrease after a certain point—Phase 3)