Paper presented in the IV Globelics Conference at Mexico City, September 22-24 2008

Globelics

Innovation, technological capability and competitiveness: catching-up policy issues in evolutionary perspective

From low-level equilibrium traps to sustainable, innovation-based, competitive advantages

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1. Introduction

Knowledge-related variables are gradually gaining currency as vital drivers in developing countries' quest to catch-up in productivity and income. But the successful recent experience of the few along these lines has for the most part not been followed up in the developing world at large. This is shown, for example, by the de-prioritization of competence building in resource allocation by most developing countries during the last decade or so. [3]

At least three reasons can be pointed out for this lack of congruence between what admittedly needs to be done and actual policy responses. To begin with, the search for Pareto optima built into conventional policy prescriptions diverts the attention from priority competence building issues, since the price system often fails to serve as a guide for policy-making.[4] Then, effective informational feedback mechanisms with the private sector on systemic failures and their remedies, which are indispensable to prevent policy-makers' errors stemming from uncertainty and imperfect knowledge, are seldom given priority[5]. Lastly, appropriate tools, heuristics and metrics as well as methodologies for needs assessment and strategic prioritization, including those relating to policy capabilities themselves, are hardly available. Releasing these mutually reinforcing policy-related constraints and focusing on the stimulation of the demand for scientific and

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[3] As far as human development is concerned, without which competence building can hardly proceed, the UNDP states: "If current trends continue, the MDGs will be missed by a wide margin. Instead of seizing the moment, the world's governments are stumbling towards a heavily sign-posted and easily avoidable human development failure…" UNDP, 2005, chapter 1, p. 17. More specific indicators, such as those relating to national expenditures on R&D, trade capacity building and capacity building programs for agricultural improvement, including the training of agricultural scientists, only add to this dismal picture.
[4] While the price system understates the demand for innovation because markets tend to under-reward innovation, system weaknesses often block the supply of skills and expertise, as well as their application to innovative activity.
[5] This, in turn relates to the resiliency of the linear view of the innovation process.

technological talent through innovative approaches to private sector development have been among the keys to successful catch-up experiences.

Since structural change, particularly in a developing context, is seldom if ever seamless and automatic, unlocking its virtuous interplay with economic growth normally requires deliberate capability building actions (Kuznets, 1971, Chenery et al (eds), 1986, Saviotti and Pyka, 2002, Fagerberg et al., 1999, Fagerberg and Verspagen, 2007). Dynamic policy approaches are called for to overcome system failures in the development of both, innovative capabilities in the business sector and the scientific, technological and higher education (STE) infrastructure (e.g., Teubal, 1997) [6]

While the need for proactive competence building policies is hardly in contention at the level of discourse, its effective incorporation into the national policy mix is less than fully understood. An integrated policy perspective to underpin actual and context-specific policy-making is still missing. To fill this gap, we discuss below a system evolutionary perspective relevant for both, developing and developed countries. Some attempts along these lines have been made.[7] However, much remains to be done. One major hurdle is incomplete knowledge about innovation systems, their desirable context-specific properties, and their emergence and transformation dynamics.

Although the innovation system approach is well on its way to become mainstream[8], not enough is still known about the dynamics of innovation system's formation and growth. This is particularly the case in developing countries, where the conditions for the emergence of such systems feature stubborn failures on which cogent policy answers are urgently needed but still largely wanting (Sercovich and Dolun, 2005). The absence of a sufficiently articulated understanding of *differentiated policy development processes*, including the respective institutions and capabilities, is another stumbling block (Teubal, 2002).

Effective competence building policies rely on the evolving interaction between *business innovation*, *knowledge systems* and *policy learning***.** In conjunction, they amount to a collective enterprise within which the mastering of the interplay between the public and private dimensions of knowledge is key. Incentives to the development of business innovation cannot yield success in the absence of social and policy capability development (Sercovich and Dolun, ibid). But this cannot take place at once. Countries acquire these capabilities along variegated long-term trajectories. Some common features can, however, be discerned for purposes of policy development. A stylized conceptual framework on this is submitted and illustrated below and the respective implications discussed.

In this paper we pursue three specific objectives:

i. Submit an evolutionary view of long-term structural change[9]

[6] Non-market institutions supply the main governance structure in a broad range of activities where market exchanges fail to provide appropriate, effective outcomes (Nelson, 2005). Those relating to the scientific, technological and higher educational activities are key among them.
[7] Avnimelech and Teubal, 2008a.
[8] This approach already informs policy in a good deal of countries and multinational financial institutions.
[9] The respective empirics rely largely on Imbs and Wacziarg, 2003.

ii. Present and illustrate the basic elements of a systems evolutionary perspective to innovation and technological policy-making, taking both capability building and other dynamic factors on board; and
iii. Demonstrate applications of the framework.

The systems evolutionary perspective presently adopted seems particularly suitable to address knowledge-based economic growth in the present phase of globalization.

2. Phases in structural change and knowledge-based economic growth

Long-run economic growth can be depicted in terms of two interacting dimensions: one has to do with the phases of structural change and economic growth; the other is about policy development. This section focuses on the former. Our approach restates Imbs and Wacziarg, 2003 (I&W from now onwards) within an evolutionary framework.[10] The next section discusses the unfolding trajectory of the matching policy development dimension throughout innovation and technological policy phases.

2.1. Testing Existing Theories

As economies grow, sectoral production and employment become more diversified until fairly late in the development process. Then incentives to specialize ensue as driving force (I&W). Export development appears to follow a similar pattern (Benefictis et al., 2007). Concurrent and interacting diversity generation and selection/reproduction processes underpin – and get entwined along – this long-term trend.

I&W set out to characterize the pattern of sectoral diversification along the development path. From this perspective, they survey data on sector-level employment and value added for a wide cross-section of countries at various levels of dis-aggregation. They detect a U-shaped pattern as per capita income grows, with sectoral diversification ensuing over a range of income values, followed by sectoral concentration only at rather high levels of income per capita. This finding contrasts sharply with the monotonic relationship between diversification and income predicted as a result of income effects on consumption shares (Deaton, 1997)[11]. Far from standard theories, the U-shaped pattern is consistent with a dynamic Ricardian interpretation based on the interaction between productivity increases and changes in trading costs.

I&W findings challenge the prediction of sectoral specialization based on efficiency reasons associated with comparative advantages and with increasing returns and geographical economies of scale except once a relatively advanced stage of industrialization sets in (Feenstra, 2004).

If sectoral specialization occurs only in relatively high-income economies, and countries do in fact diversify over most of the earlier development path, the conventional view of comparative advantage breaks down: The key to economic development would thus not be the standard 'comparative advantage' stemming from specialization but, rather, the acquisition of mastery over a growing range of activities. And yet, clearly, only few countries manage to conduct a sustainable diversification-driven growth – most failing to

[10] See Nelson, 1995 and Foster and Metcalfe, 2001.
[11] This interpretation is also informed by portfolio arguments (Acemoglu and Zilibotti 1997, see sub-section 2.2.2.)

bridge the income and productivity gap with the more advanced economies, as they are unable to sort out systemic hurdles associated with technological, informational and coordination externalities. Diversification is not a natural process in an increasingly integrated world economy.[12] It will not happen or will likely become truncated or delayed because of, inter alia, the absence of policy development.

2.2 An Evolutionary Interpretation of Structural Change

Provided that, when present, low-level equilibrium traps are overcome, we posit that economies traverse three main stylized, structural change-related phases as income per capita rises over time. These phases (processes, not states) are characterized by various mixes of *diversity generation* and *selection/reproduction/development* events[13], eventually leading to dynamic comparative advantages revealed through new sectors and product classes with the potential to become sustainable to the extent that they can accommodate changing competitive conditions in the world market. They, both result from, and cause the progressive formation and growth of a country's innovation system.

2.2.1. Phase 0 (Ph 0) – Low-level equilibrium

Although the template Malthusian Ph-0 did protractedly precede the raise of capitalism, neither it nor its variants are a necessary phase of modern economic development in general. Nevertheless, they do currently bedevil many least developed countries (LDCs).[14]

Reduced to its bare fundamentals, Ph-0 is characterized by economic and social stagnation around subsistence levels as a result of the lack of savings and capital accumulation, absence of productivity gains and wanting human condition[15]. Within it there is little or no scope for the development of innovative capabilities.

Such kind of regime, long-standing and ubiquitous in the history of the world economy, is still very much among us, albeit with a changed dynamic. Overcoming Ph-0 entails two

[12] Diversification is just one feature of the much more complex process of structural change. See discussion in the light of evolutionary theory in subsection 2.2. Although I&W do attempt to characterize the evolution of industrialization through the pattern of sectoral diversification, their interpretation is not explicitly evolutionary.
[13] For these are evolutionary theory concepts; see Foster and Metcalfe, op. cit. and Metcalfe and Foster, 2004. Sometimes selection is visualized as prior to, and separate from, reproduction/development of the entity being selected. Selection means a reduction of variety, while reproduction/development means an increase in the share of the variant selected in the total population. In some cases the latter may involve the creation of multi-agent structures or higher level organizations like sectors, markets and clusters (these will possess *emergent* properties and organizational forms. For a simple statement of the nature of emergence, see Odell, 2000). For our purposes here it can be said that in these cases selection occurs at the 'sector' rather than at the 'firm' level.
[14] This predicament affects mostly some fifty-eight small countries, particularly in sub-Saharan Africa and Central Asia, accounting for nearly a billion people who lag considerably behind the rest of the developing world in human development (see Collier, 2007). These countries were worse off by the turn of the millennium in *absolute terms* that they were 1970. Collier distinguishes four kinds of trap: the conflict trap, the natural resource trap, that affecting land-lock countries with 'bad' neighbours and that of bad governance (Collier, op. cit., Part 2). Sachs (2006,. chapter 3) also distinguishes various kinds of (interrelated) traps, including those caused by poverty itself, physical geography, demography, fiscal issues and governance. These traps often burden the countries concerned simultaneously (in various mixes) or in sequence.
[15] For an early contribution on this issue see Nelson, 1959.

transitions, relating to human development and productivity, particularly in agriculture, respectively.

2.2.1.1. Human development transition

Prior to the industrial revolution, population remained nearly stagnant in the very long run[16]. Instead, the population of LDCs currently trapped into Malthusian-type predicaments tends to grow fast, thus aggravating poverty. In today's industrialized societies the human development transition, which includes health, educational and environmental dimensions, in addition to the demographic one, was triggered by gradual investments in human capital associated with the acceleration of technological change (Galor and Weil, 2000). In fact, human capital formation and fertility reductions went hand in hand with technological change, productivity gains and improvements in living standards. Put other way, the human development and productivity transitions coevolved endogenously.

Because of different initial conditions, including those relating to income distribution and access to education (Rodrik, 1996; Stewart, 2001), the LDCs of today are prevented from following the sequence verified in both, the industrialized and the successful catching-up countries. Furthermore, the burden of famine, diseases and ethnic and tribal conflicts incites a high birth rate and low investment in human capital (Sachs, 2006). Rather than *resulting* from technological change and human capital investment in the long run, human development has largely become a *necessary condition* for economic growth to take place.[17]

2.2.1.2. Productivity transition

Closely linked with the above, the productivity transition, fundamentally in agriculture, is another *necessary condition* to supersede Ph-0. Such has been the case in Asia and Latin America, where most countries managed to experience a take-off in agricultural yields during the 1960s and 1970s. In the case of the successful catching-up countries of East Asia this was accompanied by widespread basic education and relatively low income inequality. Although prospects are beginning to look a bit brighter, most LDCs are still far from entering this transition. For instance, for the best part of the last half a century, agricultural yields in sub-Saharan Africa have remained essentially stagnant, while those of South and East Asia have nearly tripled (Otsuka and Yamano, 2005).[18]

[16] The rate of growth of the population from the beginning of our era to 1750 has been estimated at 0.06 per cent per year (Livi Bacci, 1997) whereas the rate of growth of GDP per capita between the sixth and the sixteenth centuries was approximately nil (Maddison, 1982).

[17] Two hundred and fifty years ago the difference in income or productivity per head between the riches and poorest country in the world was approximately 5:1; today this difference has increased to 400:1 (Landes, 1998). The ensuing gap in capability between the countries at the bottom, on one hand, and the industrialized and catching up countries, on the other, only aggravates the challenge since it entails a growing marginalization of international trade, capital and technology flows, featuring what Collier (op. cit,) calls an increasingly 'hostile' environment. As a result, relapses into Ph-0 by countries that manage to break low-level equilibrium traps by enjoying growth spurs thanks to events such as improvements in their terms of trade or natural resource discoveries, cannot be ruled out. The priority to be given to human development in this context has been acknowledged by the donor community through the U.N. Millennium Development Goals, although clearly income-poverty needs to be tackled in an equally forceful way.

[18] Furthermore, the British industrial revolution is considered part of a very broad productivity advance, including agriculture, during 1760-1860 (See Crafts, 1985).

In the industrial countries, accelerated industrialization induced the demographic transition. Increases in income due to technological change gave raise to spending more on education and this, in turn, led to the demographic transition (largely through substituting quality for quantity in child rearing). During the early stages of industrialization there actually was a substantial increase in population growth that only later got reversed through a demographic transition entailing significant reductions in fertility rates and population growth, which helped to translate technological change into raising income per capita. Thus, human capital became crucial during the second phase of industrialization (Galor and Weil, op. cit.).

Different is the sequence nowadays. The productivity and the human development transitions need to be looked at as complementary triggers of industrialization. Productivity growth in agriculture goes hand in hand with improvements in infrastructure and irrigation and, more particularly, with internal migrations, urbanization, social mobility and a growing industrial labour force, thus feeding the demographic transition by encouraging fertility reductions and inducing investments in skill acquisition. In turn, the human development transition, by releasing demographic pressures, reducing gender inequities and valorising human capital, eases productivity growth and facilitates increases in income per capita.

Ph-0 today requires a specific, differentiated policy approach, where the absolute priority is addressing human development (nutrition, health, housing and education) along with releasing stubborn infrastructure, environmental, governance and productivity constraints (especially in agriculture). These are indispensable enabling conditions to attain, at least partially, the transitions that come prior to addressing the kind of issues discussed in the bulk of this paper.
The human development and productivity transitions need not be completed for a country to enter Ph-1, during which those transitions can get deepened and consolidated. But the insights on this matter cannot be gleaned just by looking at the aggregate relationships between income, population and technological change. One needs to dig deeper into the nature of the selection/variation/reproduction processes involved.

2.2.2. Phase 1 (Ph-1) – Variety Generation and the Beginnings of Firm-Level Selection

During Ph-1, as income per capita grows, variety generation and diversification tend to prevail over selection and reproduction/development. On the whole, this helps, *inter alia*, neutralizing the impact of sector-specific shocks by reducing aggregate volatility (Acemoglu and Zilibotti, 1997). This, provided that the effects of income growth on demand patterns -- Engel law -- are not prematurely overridden by the forces driving efficiency gains[19].

[19] The way trade opening is conducted may strongly influence the relative strength of these two influences. Evidence for China, for instance, suggests that, after trade was opened, the concentration of industries across provinces fell, at least for some time (Young 2000, Naughton, 2003, Poncet 2003). In I&W the stages of diversification result from the interaction of productivity increases and trading costs. In a dynamic Ricardian model with a continuum of goods, aggregate national productivity gains relative to the rest of the world entail a broadening range of domestically produced goods. Depending on the course of the relationship between relative productivity and the fall in transport costs, countries are predicted to diversify until a stage is reached where the forces of concentration begin to prevail. Such would be the case, for example, when closing the technological gap becomes increasingly difficult whereas transport costs decline linearly or if the technological gap falls at a constant rate but the decline in transport costs accelerates as

Ph-1 features the pervasive surfacing, alongside already existing traditional activities, of varied new ones, mostly led by non-R&D innovative small firms.[20] These new activities are largely experimental, i.e., not fully competitively tested. They represent evolutionary variation. This does not mean that a measure (or the beginning) of selection processes cannot take place already during this phase. Selection at this stage, however, will occur largely at the firm level or even at lower levels of organization, such as individual products or processes new to the organization or to the economy, rather than at the product class or industry level. To this post-variation process we call *type a* selection [21] Moreover, it is conceivable that in some cases 'selection' in Ph1 might rapidly lead to evolutionary 'reproduction/development'. Thus, as soon as pioneering activities materialize, if and when *prima facie* commercially feasible, they may begin to get diffused, triggering a process of learning, rationalization, efficiency gains, imitation and new firm entry which would eventually drive relatively less successful firms out of the market. Still, during this phase, the forces of diversity generation (predominantly related to firms rather than to industries) on the whole override those of selection/reproduction/development.

A successful Ph-1 also involves the creation of a broad set of innovation-related competences that facilitate a deepening of selection (both by the market and, sometimes, by means of policies seeking to overcome market and system failures) as well as reproduction in subsequent phases. This, in turn, requires a sufficiently broad and diversified variation process. Indeed, with the exception of a few specialized, largely export-oriented and, often, natural resource-based firms, most business enterprises during this phase undertake a variety of technical, organizational and managerial learning processes across a broad range of activities. In subsequent phases, and in response to capability acquisition, on the one hand, and to market opportunities, on the other, these processes become progressively more focused, specialized and differentiated as the economy attains higher levels of development. Thus, only once business enterprises, along with their complementary agents, have acquired broad-spectrum innovative competences, as it tends to occur during the Ph-1, can they afford to seek more specialized innovative capability development tracks in subsequent phases.[22]

2.2.3. Phase 2 (Ph-2) – Deepening of Selection/Development

During Ph-2 a deepening of *type b* selection takes place i.e. a selection characterized by the emergence of higher-level organizations, such as new industries, clusters and markets. [23]. More and more successful firms test their competences in competitive markets at home and abroad and begin using innovation-related adaptive and recombinant

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capital is accumulated. I&W conclude, along with Chenery and Syrquin 1975, that structural change during industrialization responds endogenously to trade policy and economic growth.

[20] Globalization makes it increasingly feasible for a subgroup of industrializing economies to also generate a small segment of innovative, R&D-based, small and medium-sized enterprises (SMEs) rather early in the process.

[21] *Type a selection* processes take place predominantly at the level of the individual organization and is for the most part governed by the market.

[22] Policy-makers in Ph-1 must also assure the existence of a basic set of science, technology and higher education institutions to sustain the accelerated innovation required for subsequent phases.

[23] *Type b* selection is also governed by the market or could be mediated by a policy-driven strategic thrust, which becomes possible as innovation systems grow and mature. Ideally by Ph-3 the national economy can be expected to have generated a 'generic' targeting capability (Rodrik, 2004)

production and design engineering capabilities as an input in their efforts at enhancing competitiveness. In this they are spurred by interactive learning from user/supplier relationships and, less often, enlightened public policies addressing systemic failures that block innovative development.[24] Note that the growth of experimental activities by small, non-R&D innovative firms does not cease during Ph-2 at all – neither they do subsequently, although their quality may differ.[25] Particularly with the advent of new generic technologies and new fields of application thereof, they may get revitalized, often as high-tech spin-offs and start-ups.[26] During Ph-2 the balance between variation, on the one hand, and *type a* selection, on the other, shifts towards the latter. Moreover in a sub-set of cases, groups of firms comprising a proto-industry, i.e., the early stages of what potentially may become a new industry in Ph-3, make their appearance. Simultaneously, other pre-emergence conditions relevant to these industries may spring up (see below), some resulting from policies while others from new opportunities in the global or domestic environments. This will occur in a relatively small number of areas.[27]

2.2.4. Phase 3 – Selection of Sectors and Other Multi-Agent Structures

During Ph-3, selection *type b*, which, as suggested, may have started earlier on, begins to prevail. Higher-level organizations (new industries, clusters and markets) will normally require a measure of policy targeting. They will also rely on a systematic allocation of resources to a process of innovation viewed as a *collective enterprise,* that is, within an institutional and policy set up where strategic priorities are identified or re-defined. Systemic failures relating to finance, skills, information and coordination are tackled and get gradually overcome, with the public dimensions of knowledge being taken advantage of more fully than before. Neither new activity creation nor *type a* selection necessarily cease in Ph-3, since they are key to the renewal of cycles of structural change, regardless the level of income.

The envelope of the three logistic curves in Figure 1 below shows the change of per capita income (y axis) of an economy that traverses the three phases described above (the x axis is time). Ph 0, or schedule J (J=0), where little if any income growth occurs over time, is depicted by a(n almost) flat line.

Let schedule J (J=1,2,3) show income per capita as a function of time resulting exclusively from the typical diversification/specialization activity which occurs in phase J – "variation" in curve 1, (without neither type a or 'firm level' selection nor type b or 'sector selection' having taken place), type a selection for curve 2 and type b selection in curve 3.

Schedule 1 represents the time pattern of income per capita for an economy that *does not manage to shift* in a significant way towards firm selection, let alone sector selection. This may be the outcome of lack of capability building and weak policies. It lies under

[24] Policies underlying the rise of Embraer in Brazil and internationally competitive semiconductor firms in Taiwan are examples of this kind (see Cassiolato, J.E., R. Bernardew and H. Lastres, 2003 and Mathews, 1997)

[25] For instance, the emergence of a group of innovative firms that initiate formal R&D activities may be stronger in Ph-2 than in Ph-1.

[26] Biosidus and INVAP, both high-tech firms from Argentina, are examples of spin-offs prompted this way.

[27] Conceivably, in some contexts, and for an even smaller subgroup of these firms, the beginning of emergence of a new industry may take place. Hence, some *type b* selection processes, which are typical of Ph-3, could ensue already in Ph-2 (see below).

the envelope or maximum output obtainable (which reflects the impact of post variation selection) processes. Similarly Curve *Ph2 (Curve Ph3)* after its intersection with Curve Ph1 *(Curve Ph2)* represents output per capita in the economy which results both from "full" variation and from full 'firm selection' *('firm- and sector-selection*). [28]

[Fig 1 around here]

The deeper explanation for the existence and shape of the above schedules lies in some notion of *creation, consolidation or maturity* of the relevant multi-agent entity (sector, cluster, market). In Ph-1**,** although many firms experiment with new products, processes and organizational forms, very few have achieved a enough consolidation to yield a lasting and stable effect on output. Most firms represent fleeting phenomena, and may fail shortly after having started up. Similarly, in Ph-2**,** a measure of consolidation or maturity, and thereby of impact stability, is achieved at the level of individual firms, but not at higher levels of organization, e.g. a sector or cluster. These multi-level structures can attain economies of scale and advantages of intra-firm cooperation and division of labor latent within the prior set of organizations; and would also thereby, represent a stimulus for the creation of new firms. On both counts Schedule 3 should lie higher than Schedule 2 after a point.[29] As they proceed, these evolutionary transitions give raise to productivity gains that get increasingly diffused across the economy over time.

3. A three-phase policy perspective

Each policy development phase to be reviewed next within the context of the long-term view of growth and structural change discussed above is characterized by a blend of three dimensions: namely, i. *Market and system failures* blocking the unaided attainment of such priorities; ii. *Overall objectives* and s*trategic priorities*; and iii. *Policy mix.*

These dimensions bear close relation to the *structural deficiencies, weaknesses and opportunities* of the economy. Since this is a generic model, we stress here objectives and priorities rather than specific policies.[30]

3.1. Phase 1- Promoting innovation and experimentation, setting up a STE institutional infrastructure and establishing threshold framework conditions

[28] Schedule 2 lies below Schedule 1 to the left of the intersection of these two curves. This implies that the output per capita that could be generated from 'firm selection' when there is no systematic variation is lower than that which could be generated by 'variation' only. This is obvious since a condition for effective firm selection is a sufficiently broad process of 'variation'. Similarly considerations explain why Schedule 3 is to the left of its intersection with Schedule 2 lies below Schedule 2.

[29] In the figure the critical point is represented by the intersection of Schedule 3 with Schedule 2. The former lies below the latter to the left of this intersection because the successful emergence of any one higher level structure ('sector selection') may critically depend on the appearance of one or more individual firm with a sustainable competitive advantage, i.e. who have achieved consolidation in the relevant area. The more we move to the right the more firm selection has taken place and the larger the number of potential new sectors or industries that could emerge.

[30] For instance, important governance and regulatory policies, such as new regulatory frameworks for infant industry, may be needed already in Ph-2, as the Chilean case in illustrates (J. Katz, 2004). Likewise, intra University governance issues may also have to be tackled, such as allowing professors to set up start-ups, to do proprietary R&D for companies, and to share in the licensing benefits from patented technology (see respective 1999 legislation in France).

3.1.1. Structural Deficiencies, System Weaknesses and Opportunities

The relative weight of the respective features (see Box 1) will vary according to country-specific institutional and structural conditions, giving rise to variations of the generic case.

[Box 1 around here]

3.1.2. Strategic priorities, system failures and action areas

As an overall goal, Ph-1 seeks to establish framework conditions for innovative entrepreneurship development. This will mean actions aimed at overcoming structural deficiencies relating both to the business sector and to the support infrastructure as shown in Box 2.

[Box 2 around here]

3.2 Ph-2 - Accelerating innovation and firm-level (type a) selection and creating conditions for future policy targeting

The general goal is creating conditions for: i. *Internalizing/endogenizing business innovation* across the economy; ii. *Enhancing networking and interactive learning*-both in general and with a focus on the future international expansion of specific infant activities, product classes and clusters (either through market forces and/or policy interventions) ; and iii. *Promoting a set of organizations able to seize the advantages of globalization* (access to global markets, resources, partners). Only a few top-tier industrializing economies have traversed successfully Ph-2 (e.g Republic of Korea, Taiwan Province of China, Singapore, Israel). Most countries have stalled in this phase (see below). Key structural deficiencies, system weaknesses and (latent) opportunities are indicated in Box 3. Strategic priorities, system failures and action areas are shown in Box 4.

[Box 3 around here]
[Box 4 around here]

3.3 Phase 3: Accelerating innovation and the internationalization of the innovation system. Emergence of new infant industries, markets and clusters,

Box 5 provides a detail of the key characteristics of the policy approach in Ph-3. Note that the central policy thrust in this phase is geared to new knowledge-based product classes, networks, sectors and innovation systems, including venture capital/private equity markets, the development of standards-setting activities and public/private partnerships, in the context of a considerable degree of exposure to global competition and the application of advanced targeted policies.

[Box 5 around here]

3.4 Variations of the general model

The sequences across phases are far from regular since they do not occur evenly across the board and may, therefore, feature differently across countries, sectors and regions.

Policies may likewise vary according to specific initial conditions within each phase. Some countries, like Israel during the late 1960s or India and Russia today, may have excellent STE infrastructures, but be retarded in business innovation. In these cases, triggering the virtuous STE-innovation co-evolutionary process may require direct support to business innovation (this condition embodies the *system failure* addressed by policy). This variant of the general model assumes that the strong *push* to innovation entailed by a well-developed STE infrastructure may not suffice to trigger the required co-evolutionary process. What is lacking is *pull* i.e. "demand" or incentives by business firms to undertake R&D and innovation and valorize the related capabilities in their competitive inroads. This may come about through direct support; e.g. through specific subsidies business innovation. Moreover, once innovation in the business sector acquires momentum it will, through derived demand for S&T inputs and for skilled manpower, stimulate the STE infrastructure itself (hence, 'innovation' becomes a source of pull for the STE infrastructure).

Conversely, in countries that lack a well-developed STE system, simply providing direct incentives to commercial innovation will not suffice since the STE infrastructure cannot respond by providing additional knowledge, technology and skilled manpower inputs. The system failure to be overcome by policy in this variant of the general model must also involve, not just direct, but also *indirect* support to business innovation by means of actions addressed to strengthening the STE infrastructure.[31]

3.5 How endogenously driven policy is?

Policy-related needs and effectiveness are strongly affected by relative advances and delays in the development of innovation systems' structural features, including their differentiated policy capability components. However, these can hardly be expected to translate in automatic or purely endogenously given policy responses since, for instance, strategic priorities have to be determined within a number of possible alternatives, requiring the exercise of discretion and judgment. Moreover, a virtuous co-evolution process may take place between the adaptation of an innovation system to the impact of past policies and new policy responses to emerging opportunities.[32] When innovation systems face radical changes in environment such co-evolution requires the guide of search, vision determination and strategy formulation. The latter is subject to a large scope of variety as well as to fundamental uncertainty and serendipity.[33] This is one of the key reasons why differentiated policy capability development is an important component of innovation systems**.**

[31] In this case the promotion of commercial innovation requires a combination of push and pull actions.

[32] Throughout the sequence of phases cumulative processes with positive feedback are triggered and fuelled by the conditions created by previous phases. However, radical external challenges, such as paradigmatic shifts may raise new challenges and truncate the 'natural' evolution throughout phases or alternatively, create new opportunities for continuation of cumulative processes by shifting to a new 'engine of growth' (this was the case in Israel where the cumulative process initiated in the early 1970s by the direct grants to business sector R&D, which was weakening during the second half of the 1980s, received a big push forward by the policy promoting the venture capital industry/market (Avnimelech and Teubal, 2008a). Thus, the outcome may be the start of a new cycle or the reset of a current one before its completion.

[33] Fundamental uncertainty occurs when information from past events cannot be used to form statistical probabilities over the outcomes of future events, since each event is distinctive and novel (Knight, 1921).

Tapping the international policy experience according to domestic needs is another important feature. Skills to do so remain poor and un-addressed in most of the developing world -- this being hardly offset by means foreign policy advise. This is the reason why many attempts to draw on such experience end up in failure. The point is engaging less in viewing the domestic development issues in the light of the experience of successful catching-up countries as is often done and more in assessing the latter's experience in the light of the specific circumstances of the countries that fail to catch-up, with due attention paid to initial capability endowments and to the underpinnings of the ensuing capability building dynamic (see Sercovich and Dolun, 2005 and Sercovich et al., 1999, especially chapter 1).

Assessing policy needs and efficacy entails, first of all, identifying and addressing systemic failures in the current institutional set-up that block capability building along strands conducive to the development of dynamic comparative advantages. Non-market institutions are at the core of such institutional set-up (Nelson 2005). This includes most of the institutions of the knowledge-subsystem (regulatory agencies, training institutions, universities, technical associations and so on). These advance along their own tracks of capability accumulation – as do differentiated policy capabilities – and have a decisive impact on socio-economic outcomes, over and above whatever the self-transformational properties of market systems are.

3.6. Success and Failure in Transitioning to Ph-3[34]

In this section we first briefly address transition and emergence issues with a focus on entry into Ph-3. We distinguish two basic stylized models of successful emergence of multi-agent structures (MAS) such as those consisting of new product classes, markets, industries or clusters in the transition to Ph-3. To one we call "*market-selection driven"; to the* other "s*cience and technology-led"*. Then we examine cases of success and failure in entering Ph-3.

3.6.1. Market-selection driven emergence

This case is based on market selection of the most competitive firms in Ph-2. One example is that of venture capital firms and start-ups that originated in Israel in the 1980's and early 1990's prior to (or during the early) emergence of that country's venture capital industry/market & the entrepreneurial high-tech cluster, which they ended up being part of. These firms were then leveraged into multi-agent structure (which laid the ground of the evolutionary targeting concept (Avnimelech and Teubal 2008, Sercovich and Teubal 2007). Another example of 'market selection' at the firm level is ARCOR, a highly integrated Argentine candy and chocolate multinational that competes head-to-head with the leading multinationals in the sector such as Nabisco Holdings Corp and Cadbury Schweppes PLC. This firm was instrumental in consolidating an internationally oriented, highly competitive candy and chocolate product class in Argentina. In contrast with the key role to be played by government-promoted entrepreneurial high-tech cluster in the case of the development of the venture capital industry in Israel, ARCOR's case is a much clear-cut case of 'market selection driven' emergence, i.e. in its unremitting technological progress and raising quality standards, ARCOR hardly drew on the domestic STE infrastructure.

[34] This section heavily relies on a draft by the authors with the provisional title "Two models of policy targeting with factual/counterfactual illustrations" (forthcoming)

3.6.2. STE-led emergence

This variant is based on the successful development of a technology-specific infrastructure that 'nurses' key precursor firms, which then get metamorphosed into a new sector or industry. A good example of this kind is Taiwan's semiconductor industry during the 1980's. In this case, the initial firms originated as spin-offs of the state-sponsored Electronics Research and Service Organization (ERSO), which absorbed and then transferred US integrated circuit technology, helping to train manpower and launch start-ups by means of the Industrial Technology Research Institute (ITRI). Another example is that of the Brazilian enterprise Embraer, which was formed by professionals trained by a state-sponsored S&T institution (the Aeronautics Engineering School, which in 1946 became the Aeronautics Technology Institute -- ITA in Portuguese) and then massively transferred to Embraer, subsequently becoming the human capital backbone for the initial stages of this successful Brazilian-based multinational aircraft manufacturer.

As implicitly suggested already, the distinction between *market-selection driven emergence* and *STE-led emergence* often is *not absolute* since certain science and technology thresholds may have to be reached in Ph-2 for the *market selection driven* emergence of a MAS to take place. Thus, for example, Israel's defense R&D and general excellence in STE during the 1980's & 1990's gave rise to technological and innovation capabilities that laid the ground for 'firm selection' in software and communications and the emergence, along with venture capital firms, of the entrepreneurial high-tech cluster in the 1990s. This suggests the potential importance of *hybrid or mixed cases* of Ph-3 MAS emergence

Clearly, *STE-led emergence* of multi-agent structures in Ph-3, as opposed to that resulting from the unaided action of market forces, entails a degree of (direct, indirect) *policy targeting.* But even in the second case, where policy targeting of new multi-agent structures is absent, past policies may be influential in creating the required Ph-2 pre-conditions for subsequent emergence.

Another relevant factor is *system complexity.* Broadly speaking, the higher the systemic complexity of the activity at stake (number and variety of inter-agent knowledge flows required to bring a product successfully to the market) the greater the role of the STE and network infrastructure to cope with systemic failures ([35]). The extent of system complexity may result from globalization-induced emergence of numerous interacting markets along with the logistics resulting from the geographical fragmentation of the value chain of complex products. That of 'integrated circuits production services market', is an example provided by Taiwan's experience with its infant integrated circuit industry, which emerged during the early to middle-1980's. This enabled suppliers of innovative chips worldwide to focus on chip design while outsourcing production services to Taiwanese firms.

The interaction between market selection, policy targeting and system complexity gives raise to multiple possible sector-specific patterns.

[35] The concept of complexity above is akin to, although it differs from, that of complex product systems (CoPS) see http://www.cops.ac.uk/workprogramme/ourworkprogramme.php (accessed on 10 June 2008).

3.6.3. Success and Failure (Retardation and Truncation)

Successful cases of policy-targeted MAS emergence in the developing world are rare – and clearly out-numbered by cases of failure (retardation or truncation). The comparison between the experiences of Brazil (Embraer) and Taiwan (semiconductors) poses suggestive commonalities and lend themselves to a provisional generalization of necessary and sufficient conditions for entry into Ph3, entailing the concomitant development of MAS and generic targeting capabilities. These commonalities are reviewed further below.

The review of the evidence of failed and successful policy-targeted (and of unaided emergence) of MAS, including dynamic policy trajectories and outcomes possibly involved can be approached by focusing on: (i) Initial conditions; (ii) Incentives policies; (iii) Strategy for IS formation (including policy targeting); (iv) Business strategy and (v) Outcomes. What follows is a preliminary exploration along these lines, with focus on policy-targeted cases.[36]

Boxes 6-a and 6-b provide a detailed illustration of truncation versus emergence in the aircraft industry and venture capital industry, respectively, and spell out the factual/counterfactual variables and scenarios at play.

[Box 6-a around here]

A parallel case to Brazil's Embraer is that of ERSO/ITRI (Electronic Research Service Organization/Indutrial Technology Research Intitute) in Taiwan. In this case, a massive spinoff of personnel from these organizations during the early 1980's laid the ground for the creation of enterprises, including the two most successful in the semiconductors field. These companies started the global 'production outsourcing' market, thus allowing the emergence of 'fabless' enterprises focused on chip design (Israel had some 25 of these companies towards the late 1990's. ERSO 'targeted' semiconductor technology e and implemented technology transfer (based on an agreement with RCA of the US), nourishing in-house learning prior to 'releasing' its personnel to set up the spin-off enterprises. These two cases thus mark an interesting commonality across successful transition cases, characterized by the early tackling of systemic failures relating to information, technology and coordination by means of the creation of critical nodes within an emerging innovation system and in the framework of long enough planning horizons (see Sercovich and Teubal, forthcoming).

[Box 6-b around here]

4. Fundamentals underlying the Innovation and Technology Policy Phases

In this section we spell out some general principles underlying the perspective discussed above. The concept of *policy trajectory* whereby early policies are linked to later policies

[36] Illustration may also be offered of sustainability versus non-sustainability upon Ph-3 having been reached (or some variante thereof) for the case of advanced industrial countries such as in automobiles and consumer electronics in the US. Quite possibly, the *predominant factual* in the developing world is one of truncation in Ph-1/Ph-2 due to premature selection. The case of successful catching-up countries and that of other countries that managed to access Ph-3 in specific activities would provide an *exceptional factual*, whose stylization yields our *generic counterfactual.*

and where the objective is to generate self-sustained processes of knowledge and innovation-based growth is key in this discussion.

4.1 General Principles.

4.1.1. The Framing of innovation, technology and venture capital policies

To tackle the effective application of new policy perspectives, policy-makers need to pay adequate attention to the *framing of policies;* that is, the cognitive structures required and the (political, governance) constraints and opportunities involved in exposure to globalization. This is made vital by a dynamic and increasingly complex global environment and is illustrated below by reference to policies in support of enterprise innovation.

Traditionally such policies have sought generating more innovation or R&D in the business sector (so called *"Business Sector **R&D** additionality"* objective); the assumption being that more R&D in firms will automatically translate into more output and value added. However, under current world economy conditions this assumption cannot be taken for granted since the medium and long term impact will depend not just on the future state of global markets and global competition, but also on the capacity to access critical complementary assets (Teece 1986), including sources of critical resources in advanced economies, such as venture capital. Moreover, in turbulent global environments domestic firms also need to develop *innovation capabilities* in order to re-orient and upgrade their innovative efforts in response to changed technological and market conditions [37].

Finally, adding considerably to the complexity of policy framing efforts, the *policy trajectory* over time, including *forthcoming* policies, may exert a non-negligible influence on the total impact of policies *already under implementation*. Thus the indirect impacts suggested above will also depend on future policies directed to the STE infrastructure. These may help leverage the new capabilities, the new entrepreneurs and the new knowledge relating to areas with potential high-growth generated by current policies. The upshot is that policy framing should nowadays precede the design and implementation both of policies and of policy evaluations (see below).

4.1.2. *Emergence* as a possible innovation/technology policy objective

This follows from the relative increase in importance of sector-level (type b) *selection* in Ph-3. From this perspective, the objective of policy is to *trigger and sustain* a process of emergence of a new multi-agent entity (sector, sub-branch of the business sector, market, cluster). Emergence of new activities or clusters might be characterized as a cumulative process with positive feedback.[38] Triggering and sustaining such a process may require *targeted* rather than *horizontal* policies[39].

[37] In the longer term the indirect impact of direct support of firms' innovation may also depend on its impact on *innovative entrepreneurship* and (as mentioned in the previous section) on the creation of sets of firms able to achieve *sustainable competitive advantages* (type a selection), thus eventually laying the basis for new industries and markets (type b selection).

[38] Alternatively it could be stated that emergence is characterized by *dynamic* increasing returns; see also Bresnahan et al., 2001

[39] Horizontal rather than targeted policies are appropriate to promote 'variation' (Teubal, 1997). For this reason they should be a component of Ph-1's policy mix.

4.1.3. Evolutionary Targeting [40]

The objective of targeted programs is to trigger and sustain sufficiently rapid processes of emergence of *higher-level organizations and multi-agent structures*. In the present context, targeting differs radically both from the 'picking winner' policies of the past and from the industrial policies followed by the Republic of Korea during the 1970s (hence the term evolutionary targeting).

This new perspective focuses on generating pre-emergence conditions for a set of multi-agent structures; selection of potential targets; identification of system failures blocking unaided emergence; and the design and implementation of targeted programs. Firm-level, type a, selection or the appearance of firms with sustainable competitive advantages can be a major pre-emergence condition.

4.1.4. Intermediation Issues

A n*ew (supply-demand) intermediation form* is a pre-emergence condition for the creation of a new market and/or the emergence of a new industry. Three types of conditions are involved: I) *Dominant Product Design* (originally raised in Industry Life Cycle theory, see Abernathy and Utterback 1978, in their framework a condition for the transition from the Fluid to the Growth phase of a new industry); 2) *Product Bundling* issues due to economies of scale in market building and in transactions costs (see Antonelli and Teubal 2007 in the context of the ICT related venture capital industry/market); and 3) *Mutual adaptation of supply and demand agents and the institutional framework*. All of these require process of experimentation and learning (or alternatively variation and selection); and frequently both a favorable environment and explicit pre-emergence policies. As a result, the *evolutionary targeting* perspective needs in some instances to focus on: (i) generating new intermediation forms and other pre-emergence conditions for some industries/markets; and (ii) triggering (and sustaining) emergence processes in other industries/markets. This applies to venture capital policies in Europe (OECD, 2003). An interesting instance of *evolutionary targeting* was the Yozma program – a targeted program directed to the emergence of a domestic venture capital industry/market in Israel during 1993-98.

4.2. Towards a Typology of Policies – The Innovation/Technology Policy Mix

Innovation/technology policies include a variety of measures belonging to one or more of the following three categories: incentive programs, institutional and regulatory changes, and other policy actions/measures.

Incentive programs are of two general types – *horizontal* and *targeted*. Frequently a mix of more than one innovation/T policy category is required e.g. incentives programs *cum* institutional changes, since there may be complementary or substitutes. Moreover, the implementation of incentives programs may require attention not only to monetary incentives but also to capabilities, organization, strategy, etc. While in some cases promoting emergence may be implemented through institutional changes or horizontal incentives programs, targeting the new multi-agent structures may frequently be required.

[40] See Avnimelech and Teubal, 2006a, 2007

Targeting the emergence of higher levels of organization sharply differs with respect to the targeted policies of the past, including those involved in 'picking winners'.[41] A systemic view directed to new sectors or infant activities may have to include both *activity-directed policies* and *activity-relevant policies.* Thus targeting a venture capital industry/market may require both policies directed to stimulate venture capital or venture capital organizations *and* policies directed e.g. to promote innovation or innovative SME's or high tech Start up companies

4.2.1. Levels of policy making

The *strategic* level of policy, as opposed to the operational, may require a set of capabilities very different to those of most existing policy institutions. It involves the following activities: (i) Setting (new) strategic priorities, including new multi-agent structures; ii. Identifying *system failures;* and iii. *Initial articulation (*along with the operational level in charge of policy/program implementation) in generating a new policy portfolio reflecting the above.

The importance of the strategic level of policy increases with the rate of change in the global environment, its complexity and with countries' targeting-related needs. With the dynamic and even turbulent environment most countries face today, the possibility that existing programs/policies may not reflect updated, true strategic priorities anymore is high. The implication is that a re-assessment of these priorities becomes a critical policy action, much more than continuing the routine implementation of existing programs.

Thus not just the capabilities but also the organizational set up, the activities and the routines comprising the strategic level of policy, can be very different from those characterizing the policy institutions of most countries. While good links with the operational level of policy are key, it is also important that the governance profile assure independence of the strategic level with respect to the operational level of policy

4.3. The Context Specificity of Innovation/Technology Policy and Policy Heterogeneity

Policies cannot be derived from general principles only since they require sufficient knowledge of the institutional and other context-specific variables, including innovation system components upon which the policy will impinge (and be impinged upon). Thus, a situation of insufficient innovation in the business sector does not necessarily imply the desirability of providing incentives, nor does it imply that a specific incentives-program be undertaken. Very much will depend on context specificities (thus, widespread corruption may preclude providing direct incentives to firms) and on the possibility of generating dynamic economies of scale e.g. through the promotion not only of innovation but also innovation capabilities, innovative organizations and innovative entrepreneurship (this may depend on business culture, the existence of critical mass of agents willing to benefit from the program, and the approach to program implementation which the agency in charge will or could adopt). One outcome is policy heterogeneity. In the venture capital area, the policies to be implemented in Europe may depend on the underlying sector/cluster whose innovative SME's would benefit (high tech, life sciences or non-high tech); on the possibilities of adopting particular organizational forms (e.g. limited partnerships were possible in the US and Israel but not possible in Finland); on pre-existing links with the global VC industry; on whether or not a critical mass of high tech

[41] Targeting also involves a process diametrically opposed to those underlying horizontal policies.

start up companies already existed; and on whether or not there was an incumbent private equity industry already operating in the country or region.

4.4. Policy Promotion of Virtuous, Self-Sustaining Processes

The ultimate implication of the new approach to policy making proposed here is viewing policy as a differentiated system and process whose *ultimate objective* is promoting self-sustained processes of innovation and growth. Part of this task consists of triggering and sustaining a cumulative process involving dynamic economies of scale mentioned above; another part is the forging of explicit links among policies through time and across phases.

We briefly refer to two central axes of policy making: 1) promoting STE-Innovation co-evolution; and 2) linking direct promotion of innovation in the business sector *and* direct promotion of BS innovation policies and policies directed to the STE infrastructure with the subsequent support of venture capital and/or targeting of other multi-agent structures.

The first linkage exploits the supply push-demand pull links between innovation and its supporting STE infrastructure; the second implies a substitution of privately financed support of innovation and innovative SME's for government support (Avnimelech and Teubal 2006), calling for the creation of additional, mostly private (venture capital) infrastructures to support innovative SME's.

5. Applying the framework: new policy challenges

The following sub-sections are intended to illustrate the issues previously discussed in the light of specific fields of application, all of which are characterized by the key role played by non-market institutions in the evolution of IS**.**

5.1. Standards, Intellectual Property Rights (IPRs) and Technological Change: the Interplay between Diversity and Selection

Standards and IPRs play a leading role in shaping of innovation systems**.** Historically, both institutions advanced *pari passu* with the development of innovation systems in today's advanced industrial countries. Only since approximately the last third of the 19th century, their respective national regimes slowly began converging. This process reached a peak in 1995 with the approval of the WTO agreements on Trade-Related IPRs (TRIPS) and Technical Barriers to Trade (TBT). However, the evolution did not stop there. During the last decade, additional international agreements and, particularly, new regional and bilateral free trade agreements considerably sped up the pace of institutional (as opposed to economic) convergence across borders, involving most developing countries. As a consequence, factoring in the role of standards and IPRs has become indispensable for a proper understanding of the process of innovation system formation and development in catching-up economies, including the policy dimensions.

Because of their built-in ambivalence, depending on how the respective regimes are designed, managed and enforced, technical standards and IPRs may spur or stifle innovative activity. It is a very fine line indeed, one that needs permanent monitoring and context-specific co-adaptation – something often neglected by international guidelines.[42]

Technical standards help focus the direction of collective search efforts and help foster diffusion; but they also may limit the emergence and adoption of new technologies and products, e.g. through lock-in effects. They encourage efficiency gains from specialization, reduce information asymmetries, drive costs and prices down and enlarge markets; but they also limit product diversity and users' range of potential choices.

In developing country contexts international standards tend to become functional once exposure to international competition gains strength (Ph-2), calling for fine-tuned public/private co-operation in order to build conformity capabilities and take full advantage of standards diffusion. As the opening of the economy proceeds and competition in domestic markets increases, the need arises to watch the balance between gains in the efficiency of innovative efforts and reductions in the degree of diversity of these efforts.

These policy challenges are not at all trivial. For instance, a specific new technology may have a lower potential for improvement than an old one the former comes to replace, or the costs of shifting to a new, more promising technology, may be perceived as higher than those of sticking to the old one. As policy-makers are rarely able to anticipate technological change and time their decisions optimally, they are normally focused on creating appropriate framework conditions for standardization and rely on private committees to manage the standards-setting processes. This entails fostering the diffusion of innovative capabilities and networking in enterprises and client-oriented conformity-related capabilities in the institutional support infrastructure.

On the other hand, and depending on the scope, strength, duration and ways of enforcement, patents pose a well-know trade-off between rewarding invention and innovation and securing the diffusion of new knowledge. The kind of incentives they provide differs sharply from those given by standards. Whereas the latter encourage collective and participatory processes of innovation convergence, patents are publicly sanctioned private monopolies given in exchange for making the respective information public. In principle, their roles are complementary; one promoting selection, the other fostering diversity. And yet, their specific impact is highly context-specific and may be at odds with what is expected from them. Thus, for instance, when innovative capabilities are underdeveloped (e.g., Ph-1**)**, a strong patent regime may encourage premature selection thereby discriminating against domestic firms (particularly SMEs) while asymmetrically favoring well-established, R&D-intensive, advanced country-based companies at the expense of potentially competitive domestic firms. Correspondingly, an exceedingly lopsided distribution of technical, managerial and organizational capabilities across enterprises may also substantially prevent reaping the potential collective benefits from standardization.

With the integration of world markets, the diffusion of (largely company-sponsored) standardization and strong IPR regimes in open catching up economies tend to get ahead

[42] For instance, the World Intellectual Property Organization (WIPO) was set up in 1967 to promote innovation by means of IPR regimes, in disregard of development-specific contexts. It is only very recently that a 'Development Agenda' for WIPO began being discussed at the behest of a group of developing countries.

of the maturation process of domestic institutions. Where weak innovation systems and lacking self-regulatory mechanisms are the rule, as is the case in most countries still in Ph-1**,** such diffusion may be expected to distort and prevent, rather than help, innovative development. As innovation system mature, however, the possibility of reaping network externalities and capitalizing on rewards to innovative effort increases, which broadens the scope for the direct and indirect effects of interface standards and for drawing on IPR protection to strengthen international competitiveness.[43]

The introduction of quality and safety standards may offset lacking company reputation by reducing information asymmetries and gaining market acceptance for new products. This way, good standards management may speed up Ph-2 transition. Similarly, with the progressive spread of innovative effort, IPRs may help capitalizing on it, particularly if the IPR regime protects the kind of innovative outputs that are typical of catching up economies. Looking forward to Ph-3, active participation in standard-setting processes calls for inroads in knowledge generation by means of systematic engagement in collective, and increasingly R&D-based, innovative activity. Similar reasoning applies with regard to patents, which nowadays reward above all those able to turn out the outputs of highly R&D- and science-intensive inventive and innovative effort.[44]

5.2. Food security

Competitiveness in agricultural and food products is increasingly about the ability to meet safety, quality, and environmental requirements (over and above price and terms of delivery). Changes in how the risks involved in the food chain are perceived by the public and approached by the scientific and policy-making community have resulted during the last decade or so in steeply more stringent sanitary and phytosanitary standards and regulations in all developed and many developing country markets.[45] Greater scrutiny of production and processing techniques is being coupled by stricter traceability and

[43] In the drug development field a stronger IP regime may help ethical drug developers (who undertake substantial R&D and clinical testing of new drugs) at the expense of existing developing country based companies that might have thrived under prior, weaker IP regimes (see Sercovich, 2008).

[44] China's case is worth watching from this perspective. China aims to become a world S&T and standards-setting leader by 2020, which means having entered fully into Ph-3 in a variety of fronts within just over a decade. The idea is to strengthen the competitiveness of Chinese firms by capturing the value from successful R&D to build up *inter-operable technical standards embedded in Chinese-held patents*. This reveals full understanding that competition is moving upstream from product-markets to IPR-embedded, WTO-compatible, standards. Active participation in standard-setting activity is seen as lowering both the risks of research and the costs of development as well as decreasing the time-to-market delivery of new products. The path to this goal is anything but smooth. In Nov 2003 China announced the adoption of a home-grown encryption standards for wireless communications (WIPI) to be adhered to by all wireless devices sold in China (allegedly superior to the American IEEE standard 802.11i. In April 2004, faced with allegations of non-WTO compliance, China announces the suspension of the requirements. Between Dec 2004 and Feb 2005, two meetings are convened to bridge differences. Both fail. In March 2006, at the end of highly contended and acrimonious negotiations, the International Standards Organization (ISO) rules in favour of the American standard. In Dec 2005 China announces preferential treatment in government procurement for WAPI-compliant devices and a new WAPI industrial alliance of Chinese firms to promote the standard. Other high profile Chinese standards initiatives include third generation mobile telephony (TD-SCDMA), product tracking and remote identification (RFID), digital audio-video coding and decoding (AVS) and formats of audio-video disc players (EDV).

[45] Sanitary and phytosanitary laws, regulations, requirements and procedures are intended to protect human, animal and plant health. They comprise end-product criteria, processes and production methods, inspection, certification and approval procedures, quarantine treatments and transportation requirements, sampling procedures, risk assessment methods and labelling requirements directly related to food safety (WTO, SPS Agreement).

labeling requirements along the supply chain. In particular, the European public has become highly sensitized to uncertainties surrounding potential risks entailed in genetically modified food.[46]

These circumstances have led to a considerable increase in the threshold technological, managerial and organizational capability required in all developing countries, across the board, regardless of the extent of maturation of their domestic innovation system. Correspondingly, the pose additional demands for offsetting S&T and innovation capability building and public/private cooperation policies in pursuit of a moving target as a matter of policy priority. Therefore, it is not surprising that uneven responses are found amongst agricultural commodity and food supplying countries, even those at comparable stages of innovation system maturation as a result of context-specific circumstances. While posing a significant challenge, sometimes perceived as a barrier to trade, those demands also mean a powerful inducement for technological upgrading and entry into higher-value added food exports. The respective costs depend on the prevailing level of administrative, managerial and scientific capabilities, the scope for public/private partnership, and the strength of the existing S&T support infrastructure, including extension services.[47]

During Ph-1 only the rudiments of the necessary capabilities to meet sanitary and phytosanitary (SPS) measures are in place. They may include, save in a very narrow range of heavily export oriented activities, a bare minimum capacity to monitor sanitary conditions and little or none compliance infrastructure and capability to interact with the international system to build legitimacy while enhancing the domestic knowledge base. Large export opportunities may thus be forgone. The importance of these SPS capabilities particularly in less developed economies (where agriculture and food industries are important) is such that there may well be a need for a specific policy targeted to promote them and the associated underpinnings (this may also need to be part of a very basic set of 'framework conditions' which every country must possess in order to be able to effectively participate in a virtuous innovation based growth trajectory). The need for this kind of targeting already in Ph-1 targeting may be even more compelling for those countries who already have export oriented, natural resource based food sectors particularly as the SPS measures are becoming more and more stringent through time.[48]

In Ph-2, broader *reactive* capabilities are developed to prevent a growing gap with respect to evolving SPS measures in export markets. At this stage, some key elements of the basic infrastructure are introduced and begin interacting. Awareness building is pursued

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[46] This has led to the European Union's widespread application of the so-called precautionary principle, according to which in case of absence of scientific consensus on the potential harmful effects of an action, such as that of introducing genetically modified organisms in agricultural production, the burden of proof falls on those who have taken the action. The precautionary principle was originally introduced in the EC Treaty with respect to the environment but later extended to other fields, notably that of food security.

[47] The inability to comply with SPS measures may mean fairly substantial losses either in forgone exports or in reduced export prices. For instance, outbreaks of foot-and-mouth disease in 2000/2001 meant some $1.2 billion in forgone Argentine exports, a country that, in many respect, may be regarded as having entered Ph-2. Similarly, Argentina would be incurring losses of up to $ 1 billion per year due to sanitary problems that force that country to accept lower prices.

[48] An additional benefit of early targeting of SPS is that the new capabilities and infrastructure may underpin other food and food-related products and sub-branches where the country has strong, potential competitive advantages which can materialize, say, in Ph-2. By targeting these types of capabilities early in the innovation based growth process, countries may generate a capacity for the evolutionary targeting of a spectrum of food product classes and sub-branches in Ph-2.

as to the need to enlist the support of the STE-innovation infrastructure and R&D activities in order to keep up with the scientific and technological frontier in the food safety domain.

More specifically, this phase entails steps towards:

i. Building policy-making capabilities, including updating of legislation to enable food safety control agencies to respond to current challenges beyond basic control o hygiene;
ii. Setting and fine-tuning of public-private cooperation networks for the effective functioning of the food safety system and supporting private participation in international standards-setting activities;
iii. Strengthening technological capability within the institutions of the domestic knowledge sub-system, particularly those of the food standards and quality control agencies, through investments for technical training and to upgrade their testing and measurement, risk analysis and certification capacity, R&D efforts, ICT resources, training and organizational changes for enhance performance; and
iv. Helping to build capabilities in the private sector to deal with rising standards and gain sustainable competitive advantages through experimentation and new market formation by promoting investments in HACCP, good agricultural practices (GAP) and good management practices (GMP), traceability-related information and labeling systems and uptake of environmental technologies.

Note that all of these will promote not only type a but also type b selection, i.e. new opportunities for the policy targeting of new food and food-related product classes.

Finally, during Ph-3, *proactive* R&D-based capabilities take the driving seat, allowing progress *pari passu* or even in anticipation of shifts in the sanitary and phytosanitary (SPS) frontier, while adapting available technologies to local conditions and transferring experience with knowledge-based activities to the private sector. Systemic capabilities also develop towards fully functioning, integrated and interactive traceability systems. This involves, among other things, the introduction of sophisticated tracking technologies and the ability to respond to growing demands by engaging in a collective innovative effort.[49]

Along these phases, the quality of public/private interactions is enhanced, building on legitimation and trust, along with the raise of the respective sector-specific innovation systems.

While the costs of aligning domestic food security infrastructure and practices to international demands are immediate and rather easy to ascertain, the pervasiveness of feedback mechanisms and externalities, such as those associated with traceability systems, makes the respective benefits much more difficult to ascertain. For this reason, only an autonomous policy capability, one embedded in the reality of the private sector but, at the same, able to respond credibly to the challenges, can be experienced to rise up to the task.

5.3 Innovation Financing

[49] A modern food control agency requires, among other things, a unified system of data processing and information network on sanitary and phytosanitary activities, food manufacturing and transportation.

As a country goes across the three phases discussed above, business sector R&D gradually shifts from government financing (Ph-1) to self-financing (Ph-3). Two factors militate in this direction. First, a progressive endogenization of R&D activity as a result of cumulative experience and capability creation at the enterprise level, whereby such activity becomes progressively more important to competitive performance. Second, the creation of privately-owned finance and support infrastructures to service high tech start-ups and innovative SMEs**.** [50] Venture capital, the generic name for this differentiated financial market (Lerner, 1999), entails the channeling of financial resources to investment in high-growth companies (or companies with a high growth potential, usually innovative SMEs), whether high-tech or non-high tech. Success in this process is associated with a substantial expansion of business sector R&D and innovation, including an increase in business sector R&D in total national R&D, and an increase in R&D in GNP.

Shifting from a Ph-1 pattern of finance of R&D to a Ph-3 pattern raises the toughest challenge. Previous research has emphasized that countries can be stalled in Ph-2. This calls for policy-makers to pay special attention to pre-emergence conditions in Ph-2**,** including the creation of a critical mass of innovative SMEs, thus giving rise to a demand for such a private infrastructure, along with international links and other external and domestic factors.

A related aspect of an evolving innovation finance capability concerns the type of direct support programs to be resorted to in the various phases. Horizontal programs with a strong neutrality component are particularly germane to Ph-1 since, due to lack of policy experience in the field, policy-makers cannot know a priori the specific location of innovation/firm R&D related system failures (Teubal, 1997, Lall and Teubal, 1998). Horizontal R&D/innovation support programs are open to any firm and to any project undertaken by these firms (i.e. whatever the T, product class, technological area) as long as they are *bona fide* R&D/innovation projects[51]. Ignorance by policy makers also implies that at least a component of neutrality needs to be part of the incentives given by such horizontal programs. Neutrality in incentives may decline with experience, learning and capability creation both by firms and by policy makers. Thus in some areas firms would discover significant commercial opportunities derived from the commercialization of R&D and innovative activity and thus be willing to undertake it even with lower rates of government support. In other areas, it may found both that, although private profitability may be negative for some time, the potential social return is greater than anticipated (suggesting the convenience of increasing the rate of promotion).

The trend towards a greater selectivity of incentives may thus be reinforced when 'targeting' of new multi-agent structures as new product classes and sub-branches of the business sector, new markets or new clusters (*sector, type b selection)* progressively becomes relevant starting in Ph-2**.**[52] Increasingly targeted incentives programs would thus become central to the overall government innovation support effort.

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[50] In some case part or all of these support services are provided by foreign rather than domestic agents. A case in point is INTEL. Through its subsidiary Intel Capital it has provided some $4 billion to over 1000 innovative companies in more than 30 countries since 1991 (http://www.intel.com/capital/about.htm).
[51] This condition can be termed 'bottom up' determination of R&D/innovation projects to be supported by policy.
[52] Targeting may begin already in Ph-1, provided that clear sector/area actual or potential comparative/competitive advantages are clearly revealed. In such cases, Ph-1 direct support should involve

A critical aspect of government incentives programs particularly those undertaken in Ph-1 is identifying *program objectives.* It is clear that the objective is to generate or trigger cumulative growth processes both within each phase and across phases. Thus a focus on capabilities and on the promotion of innovative entrepreneurship (rather than simply on innovation additionality) in Ph-1 is crucial; since only thus can dynamic increasing returns eventually result and, as part of it, the endogenous growth of R&D and innovation take hold. However, a continuation of this dynamic may have to wait a successful shift to Ph-3, that is, once venture capital support emerges, either domestically or served by a global industry. Hence, to avoid getting stalled in Ph-2**,** continued support to a self-sustained process of innovation growth will entail continued adjustments to the programs directly supporting innovation and R&D in the business sector. Changes of focus or objectives over time may also be required. [53]

6. Summary and closing remarks

We have dealt with both the positive and the normative sides of a four phase, rather generic, evolutionary model of economic development and structural change, one which will hopefully lead to a new perspective on capability development and on science, technology, education and innovation policies in industrializing economies. While there are similarities with other evolutionary phase models of economic development, which were inspired in the experience of specific countries such as the Republic of Korea and Israel (see references in text) there are also important differences such as a more elaborated, generic link between the 'positive' and 'normative' aspects and the incorporation of a Phase 0 (characterized among other things by one or more low level 'traps') to the standard three phase model of the literature.

The sections on the positive side draws on Imbs and Wacziarg's model of growth and structural change where, after a Phase 0, a phase of diversification characterizes industrializing economies prior to the onset of specialization. We have reformulated that model in terms of a post Phase 0, three-phase evolutionary framework. Variation in innovation (products, processes, organization, strategy, business models, areas) is the dominant evolutionary process in Ph-1 while 'selection/development' tends to prevail in Ph-2 (firm or type a selection) and Ph-3 (higher order or type b selection). In this model firm selection i.e. the emergence of a small number of highly capable firms acceding to sustainable competitive advantages in particular areas is the basis for structural change eventually leading to the emergence of multi-agent structures such as new product classes, branches of industry, markets or clusters in Ph-3 (an example of the latter is Israel's venture capital industry and entrepreneurial high tech cluster of the 1990s. The transition, however, is not at all automatic; it also depends on the policy-induced creation of appropriate pre-emergence conditions and of appropriate targeted policy timing, design and implementation.

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a mix of horizontal and targeted programs. The share of support through in targeted programs in such mix is likely to increase over time (although this may hold under very turbulent environments and cataclysmic events)

[53] A subtle change of objective in Ph-2 from support of R&D projects in firms to support of innovative SME's has been observed in Israel. Full expression of the latter objective required going beyond adjustments in the existing horizontal support program -- eventually leading to the identification of venture capital as the focus of policy targeting in Ph-3).

The ‘normative’ dual of the above framework of analysis is also a post Phase 0, three-phase policy model where policies are linked through time and where opportunities for structural change themselves result from phase-specific, differentiated, policies. Thus, for instance, the capacity to target new ‘activities in Ph-3 will depend on the development of generic targeting capabilities starting in Ph-2. This requires actions aimed at creating a strategic level of policy, one focused on the identification of strategic priorities and their articulation, partly through the identification of system failures, in terms of a new portfolio of incentive programs, institutional changes and other policy actions.

The upshot of our analysis is further reinforcing the importance of adopting a new, systems evolutionary perspective to STE and innovation policies. This perspective is based on a series of general principles e.g. the need for policy framing, the notions of policy trajectory and evolutionary targeting, ‘emergence’ as a policy objective, a distinction between the ‘strategic’ and the ‘operational’ levels of policy; and the focus on triggering and sustaining self-sustaining processes of innovation through time.

Our paper also illustrates some key challenges, constraints and opportunities involved both, within and across phases, in the light of selected areas of intervention (IPRs, standards, food security and innovation financing). These applications suggest that the phased approach adopted here is a useful device to enhance understanding and guide policy towards structural change in increasingly knowledge-driven economies. Admittedly, this paper submits a first attempt at developing such an approach. More empirical work is needed along these lines.

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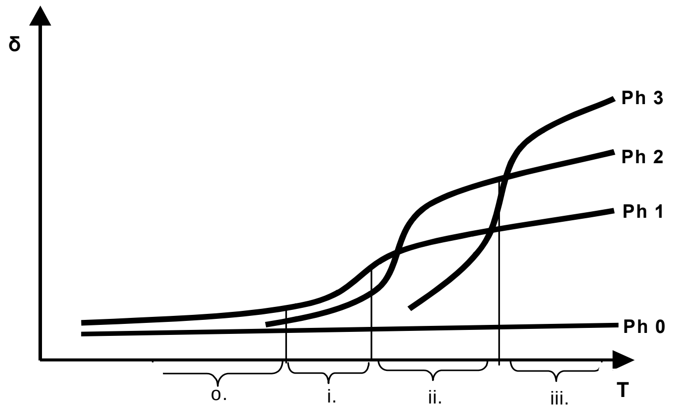
Fig 1. Long-term structural change: Phase diffusion processes over time as income grows



<u>Memo:</u>

o. Simple reproduction prevails
i. Diversity generation prevails
ii. Selection 'type a' prevails
iii. Selection 'type b' prevails

Box 1.
Phase-1: Structural Deficiencies, System Weaknesses and (Latent) Opportunities

- Very limited entrepreneurial capabilities and business engagement in innovation.
- Missing innovative networks.
- Inexistent markets for innovative products and services.
- Acute shortage of resources for innovation.
- Domestic products and services afflicted by reputation disadvantages.
- Inexistent or under-performing institutions of the support infrastructure, albeit some of them may gain a head start in certain sectors (such as agriculture).
- Paucity of laboratory, STE and training capabilities.
- Shortage of policy capabilities, especially for effective policy targeting and for capability needs assessment.
- Scarce private/public cooperation

Box 2. A.
Phase 1: Overcoming structural deficiencies in the business sector

1. Technology transfer and wide diffusion of innovative and R&D activity in the business sector, including adoption and dissemination of new technologies and applied R&D, without discriminating against (or actually favoring) SMEs;
2. Learning to innovate (including collective learning), capability development and innovative entrepreneurship
3. Fostering broad experimentation (thus generating 'variation') with different types of innovation, firms, strategies, business development models, activities, technologies, etc
4. Creating a significant segment of innovative firms across the board, including SMEs
5. Promoting the emergence and development of sectors or product classes with perceivable sustainable competitive advantages

Box 2. B. Phase 1 Supporting STE infrastructure and framework conditions

1. Ensure the establishment and effective operation of a basic set of STE institutions and capabilities.
2. Creating/adapting a network of technology and innovation support institutes geared to supporting current and, especially future needs of the innovative SME sector
3. Promoting a mission-oriented technological infrastructure in a small number of areas of vital importance to the economy (e.g., those relating to major export activities)
4. Selective and phased liberalization and opening up and nurturing of international business and academic links

Box 3.
Phase-2: Structural Deficiencies, System Weaknesses and (Latent) Opportunities

- Unstructured islands of business innovation activity, including some SMEs, with few points of contact between them and with elements of the emerging domestic knowledge subsystem.

- Firms in some productive sub-sectors acquire capabilities and legitimacy in world markets and/or the ability to identify innovation-based business opportunities, laying the ground for the acquisition of sustainable competitive advantages.

- Firms in new lines of activity emerge embedded in sector-specific innovation systems, featuring special links with universities and the support infrastructure, thus acquiring the ability to react to current challenges.

- Resources begin to flow towards innovative ventures.

Box 4. Ph-2: Strategic priorities, system failures and action Areas

1. Accelerating innovation

- Promoting innovation capabilities & generic R&D in the business sector, preferably jointly w/STE institutions.
- Attaining a critical mass of innovative SMEs
- Promoting co-operation and networking in the business sector and between it and supporting institutions e.g. universities, technology centers, government labs.
- Promoting conformity with international standards through public/private partnerships

2. Catalyzing firm-level (type-a) selection

- Identifying SMEs & other firms w/already attained sustainable competitive advantages in their respective areas
- Designing/starting initial implementation of new programs to reinforce innovation and associated firm-specific capabilities

3. Triggering and Sustaining the Co-evolution of Innovation and the STE infrastructure

- Developing of technological extension activities in ever closer interaction with business enterprises and with sectors or areas with potential sustainable competitive advantages
- Increasing focus of university/skill formation institutions on meeting demands from innovative businesses, both in general and in selected areas and technologies.
- Launching university-industry R&D Link programs

4. Promoting pre-emergence conditions for multi-agent structures

- Promoting 'generic' infrastructures sought to sustain future policy targeting of new sectors, product classes, clusters etc
- Creating and spreading international links and networks, e.g. bi-national R&D support programs, expanding grants for studies abroad, developing diaspora networks, exploitation of extant links generated by domestic multinationals or by domestic firms with significant export success; international scientific cooperation; upgrading of embassies in selected countries and signing of international cooperation treaties
- Identifying potential partners for internationalizing companies with sustainable competitive advantages

5. Promoting policy institutions and capabilities, including those directed to evolutionary targeting

- Creating strategic STE and innovation fora for the identification of emerging strategic priorities
- Developing policy capabilities for identifying new strategic priorities and for selecting multi-agent structures for targeting (sector selection)
- Monitoring and guiding search by means of specific policy instruments.
- Selecting or pre-selecting a subset of areas, sectors and product classes with sustainable competitive advantages (thus creating future options for targeting)
- Selection of technological areas (some generic, others more specific) to underpin both Ph-3 targeting and the future expansion of targeted areas.

6. Selected Liberalization and Institutional Reform

Box 5. Ph-3: Strategic Priorities and Action Areas

- New sectors and sector-specific innovation systems emerge and are promoted, partly by means of policy targeting. These sectors feature strong partnerships and links with global players. Many of them gain significant inroads in global markets

- Successful emergence of new, privately-owned finance and support infrastructures oriented to innovation by SMEs and high-tech start-ups. In some cases this will involve the creation of a domestic industry; in others an effective link with the global venture capital/private equity industry (broadly defined). In all cases a domestic market for the above equity-based mechanisms can be expected to emerge (as well as some domestic industry components and intermediaries)

- Business innovation becomes increasingly knowledge-intensive and R&D based as well as more systematic, spread and interactive by means of innovation networks

- The business sector begins to account for most national – largely privately financed -- R&D expenditures (associated with a sharp growth in the gross national expenditures on R&D/GDP ratio)

- The components of the domestic knowledge subsystem operate in close interaction with the business innovation subsystem in generating responses to emerging business opportunities.

- A generic capability for innovation-based structural change or "policy targeting" develops, including the 'strategic level" of innovation and technology policy. Needs assessment and dynamic innovation policy capabilities are implemented

- Active participation in international standards-setting.

- The training system is attuned to the emerging needs of the business sector.

- The support structure proactively searches for innovative responses to emerging needs in close cooperation with the private sector.

- Creation of public/private mechanisms assuring the continued, endogenous sustaining of a virtuous STE-I co-evolutionary process.

Box 6-a: Truncation versus Emergence in the Aircraft industry in Argentina and Brazil

	FMA (Argentina, 1927-..)	EMBRAER (Brazil, 1969-..)*
Factual	***Initial conditions:*** Heavy reliance on top-notch foreign experts working with a small domestic staff of skilled engineers and good financial backing. Sizable prospective domestic market. Motivation: national prestige. Lack of broad-based political coalition backing the initiative. ***Innovation system building and policy targeting strategy:*** discontinuous and fragmented acquisition S&T capability; poor development of managerial skills; lack of critical mass, insufficient nodes and low quality of interactions. Learning basically at the prototype stage. ***Incentives policy*:** Sporadic support through a narrow range of policy instruments and myriad political vicissitudes ***Business strategy:*** 'privatization' resulted from recognition of failure. Products designed by engineers for pilots. When the importance of the market was realized, it was already too late. ***Outcome:*** failure to capitalize on large investment and technical experience to build strategic capabilities and enter the jet market. Facilities basically reduced to maintenance and provision of services.	***Initial conditions:*** Company was started only once critical mass of well-trained scientific and engineering manpower was available to implement a well-conceived, long-term managerial and organizational strategy. Large prospective domestic market. Motivation: national self-assertion and presence in world markets. Broad-based political coalition. ***Innovation system building strategy and policy targeting trategy:*** balanced, cumulative development of technical, scientific and managerial skills meeting critical mass requirements and integrative approach to node creation. Emphasis on systems integration, manufacturing, licensing, sub- contracting and co-production. Systematic learning in production often conforming to frontier parameters. ***Incentives policy:*** Broad-based and sustained over the decades, with adaptations to meet changing circumstances ***Business strategy*:** privatization marked definite success in international market. Products designed for success in market penetration. Became a market responsive company within a decade at most. Ability to correct mistakes in time. ***Outcome*:** Only emerging country company to succeed, against all odds, in entering the majors' league. Latest development: entry into lower range large aircraft in competition with Boeing and Aerobus.

* See Cassiolato, Bernardes and Lastres, op. cit., Goldstein, 2002; Embraer, 2005, Nogueira, 2002; Broad et al. 2005; Frischtak 1992,

Counter-factual	*Entry as key player into a complex, R&D intensive, global high-tech industry led by powerful incumbents (as is the case with the aerospace industry) is an exceptional occurrence for any country, let alone a developing one. Entry barriers relate not just to the mastery of a whole set of advanced scientific, engineering and management skills. It also is a high-risk undertaking, a national enterprise. It requires sizable financial resources, meeting most stringent market, quality and reputation thresholds, riding steep learning curves, operating with very extended planning horizons, developing dense suppliers networks and forging partnerships, or competing, with key global players. For all of this reasons it requires, in particular, the capacity to engage into dynamic policy targeting in the sense of tackling systemic (coordination, information) failures early enough and articulating the supply and demand of a wide range of sophisticated capabilities over time. It also entails frontier management skills and the ability to face successfully exposure to challenges in the context of international trade agreements. These challenges are particularly acute for a developing country suffering serious human capital and technological infrastructure deficits.*

Box 6-b Truncation versus Emergence in the Venture Capital Industry in Europe and Israel during the 1990s

Factual	*Germany, France, Italy* ***Initial conditions:*** inadequate pool of start-ups, supposed to make up the 'demand' for the services of the future venture capital industry/market. Weak incentives for high tech entrepreneurship (see below). Lack of financing for early phase high tech start-ups. Bias towards financial rather than S&T skills. ***Innovation system building and policy targeting strategy*: ** focus on SMEs support. Insufficient attention to support systems for high tech start-ups and entrepreneurship. View of venture capital as a 'pool of money'. Policies seeking to 'close the early phase finance gap of high tech start-ups' rather than to contemplate the possibility of creating a venture capital industry and/or market and the related entrepreneurial high-tech cluster. Absence of a 'dynamic' view on policy. ***Incentives policy**:* Inappropriate bankruptcy laws. Lack of inducements for university professors to create companies (impossible in France till 1999). ***Business strategy:*** prevalence of risk aversion ***Outcome:*** relative weak development of venture capital financing of innovation and high tech start ups (particularly 'early phase finance') as a result of missing strategic prioritization y towards	Israel (Avnimelech and Teubal 2006) ***Initial conditions:*** Availability of "Class A" venture capital organizations. Critical mass of high tech start-ups available prior to policy targeting of the venture capital industry and the entrepreneurial high-tech cluster. Strong S&T institutions and defense R&D sector. Favorable external and domestic environments (e.g Oslo peace process) ***Innovation system building and policy targeting strategy"*** Clear strategy to develop strong S&T institutions. Unique design and appropriate timing. Focus on capabilities of the venture capital organization (Yozma) team, limited partnership form of organization, incentives to the upside and the importance of partnering with reputable foreign (and domestic) agents . Actual targeting preceded by a long 'policy process' involving changed innovation policy priorities (from expansion of business sector R&D to promoting high tech start ups) and identifying venture capital as the appropriate strategy for advancing them . ***Incentives policy:*** Strong and consistent support of business sector R&D starting in 1969, through an horizontal program with largely 'neutral' incentives. Incentives to high risk/high return financing by venture capital organizations targeted by Yozma ***Business strategy**:* Early phase finance/support of high tech start ups' strategy adopted by the new venture capital organizations (which policy helped to create) to tap high risk/high return opportunities. ***Outcome:*** very successful development of a domestic venture capital industry/market and of the related entrepreneurial high-tech cluster. Steep 'export' growth of ICT-related goods, knowledge and company shares during the 1990s
Counter-Factual	*Greater attention to the creation of favorable pre-emergence conditions and matching targeting policies oriented both to a venture capital industry/market and to entrepreneurial high tech clusters. These could include policies enhancing technological entrepreneurship and policies oriented towards creating a critical mass of critical mass of start-ups, promoting experimentation and learning on appropriate venture capital organizational forms; other cultural and institutional changes. Also greater attention to the myriad institutional and capability dimensions of venture capital and entrepreneurial clusters development; and a dynamic view of policy and of the policy process leading to the attainment of such priorities.*	*A weaker set of pre-emergence conditions would have either prevented the outcomes attained during the 1990s or, if still feasible, success would have required much stronger policy capabilities than those actually available in the late 1980s, early 1990s. Thus if the economy and capital/exchange markets would not have been liberalized during the 1980s; and if US-Israel links would not have evolved so favorably (e.g. if the BIRD program would not have existed); then the fast emergence process might not have occurred. There are also strong reasons to believe that if the 'targeted', VC directed Yozma Program would have been implemented either before or after 1993-97, its impact would have been substantially weaker.*