

6/2001

**WHAT IS THE SYSTEMS PERSPECTIVE TO INNOVATION
AND
TECHNOLOGY POLICY(ITP) AND HOW CAN WE APPLY IT
TO
DEVELOPING AND NEWLY INDUSTRIALIZED ECONOMIES?***

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*** A slightly shorter & tighter version of this paper appeared in the
Journal of Evolutionary Economics, Volume 12, Numbers 1-2, March
2002**

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List of Acronyms

ITP-Innovation & Technology Policy

BS-Business Sector

SS-Supporting Structure

R&D-Research & Development

SI-Systems of Innovation

PPP-Program Portfolio Profiles

M&A- Mergers & Acquisitions

IPO-Initial Public Offering

VC-Venture Capital

SU-Start Up companies

IT-Information

Technology

1: BACKGROUND AND OBJECTIVES

Despite significant advances in the approaches to Innovation and Technology Policy (ITP) in the literature (see STI Review, 1998) confusion still exists about how to apply such a conceptual framework in specific settings. Most discussions during the 90s emphasise the increasing importance of Evolutionary and Systems Perspectives to Economic Change (see papers in Edquist 1997) but these relate more to the processes of Innovation and Technological Change themselves rather than to *policy* directed to these areas. Moreover, whenever 'normative' aspects enters the analysis they are framed in terms so general to make it insufficient or inadequate as guides and tools for actual policymaking.¹ Underlying this paper is the view that additional theoretical and conceptual *knowledge* is required for an Evolutionary/Systems of Innovation (SI) perspective *on ITP* to be effectively applicable in a wide variety of settings..

A major objective of this paper is *to contribute to the development of a realistic and 'grounded' theoretical framework for Technology and Innovation Policy*. This is considered as a pre-condition for successful application of the SI perspective. Since the area is very broad I will be focusing on aspects which are relevant particularly but not exclusively in two contexts/ types of countries: a) the promotion of Business Sector R&D both in countries which recently have systematically initiated the introduction & diffusion of this activity and in the Top Tier Group of NIE (e.g. Korea and Israel) which have implemented such policies in the past b) the promotion of hi tech industries (particularly Information Technology and Software industries) which is becoming a major issue for both Top Tier and other Developing Countries (e.g India and China). A second aspect of our focus is our concern for the 'needs' of the business sector (direct and also indirect aspects). We will not be considering ITP directed to Health, Ecology, etc; nor that directed to the support of Science.² This does not mean that the so-called Business Sector 'Supporting Structure' will not be considered. It will, but only inasmuch as it supports the Business Sector.. On the other hand I will not exclusively be dealing with

¹ One paper that has gone beyond others in this respect is B. Johnson. See Johnson (1997). See also Teubal (1999), Dodgeson & Bessant (1996). Caracostas & Muldur (1998) and Edquist (1999)

² Some reference to Science of course will be made since it is part of Technology Policy as well as part of the Infrastructure for generating high level manpower. However I will not be directly and centrally be involved with Science Policy nor with the interface between Science & Technology.

Innovation policy narrowly speaking but also with aspects of Technology (and Industrial) policy as well.

A second objective is *to contribute directly to the capability of successfully applying this conceptual framework in concrete policy settings*. The focus will not be on providing justifications for Government support of Innovation & Technology, but in helping policy makers *apply SI principles*. Preciously few concepts and tools pertaining to ITP are readily available today, the most famous of all being two related and highly criticised notions: *market failure* as applied to R&D and Innovation, and '*market failure analysis*' (Arrow 1962, Stoneman 1988) which purports to provide the quantitative basis for estimating the subsidy to be given to R&D. That such concepts are either inconsistent with Innovation itself or inadequate as a guide to policy making has been shown repeatedly by Evolutionary theorists (Nelson 1987, Dosi et al 1988, Metcalfe 1992, among others). Despite the emergence of substitute concepts such as *Evolutionary Failures* (Malerba 1996), *System Failures* (Metcalfe 1992, OECD 1997, Galli & Teubal 1996, Smith 1991), *Technology Policy Cycle* (Teubal 1996,7) and a '*redefined*' notion of *market failure* (Teubal 1998) critical ingredients in the overall Systems ITP framework seem to be missing. In this connection I will introduce and apply the notions of *Program Portfolio Profile*, *Policy Process* and *Policy Environment*- to name at least some of those missing elements (Teubal 1999). A second means of enhancing 'applicability' of the SI perspective to policy is through linking specific principles or features of such a perspective to concrete policy actions or programs in specific settings. This explains the inclusion in the text of short summaries of programs, selected aspects of program implementation and a small number of country program portfolios (Korea, Israel, Indonesia and Argentina).

Pre-SI Perspectives to ITP

While the Neoclassical approach views Technology/Information in an abstract, aggregate way as 'homogeneous' information generated by one homogenous input 'R&D' (Arrow 1962, Stoneman, and Lipsey & Carlaw 1998) the Structuralist Perspective makes distinctions among different classes of inputs to technological development (including distinctions between 'regular' and 'generic' R&D) while emphasising the importance of 'specifying' technology. It also points out the importance of 'complementarities' in technology and in technological development and of a distinction between the Business Sector on the one hand (the locus of R&D/Innovation "used" by companies) and the Supporting Structure on the

other(Justman & Teubal 1986). These elements will all be incorporated into a Systems of Innovation perspective to ITP. Thus policy must involve a coordinated portfolio of programs of distinct types(including targeted programs which are anathema to a purely Neoclassical perspective) rather than one uniform program supporting R&D in general.³ Moreover, the structuralist perspective as presented by Lipsey and collaborators, through an analysis of limitations in the conceptual foundations of neoclassical theory(unique equilibrium, existence of an optimum and full information on them by policy makers) assumes that there inevitably will be an element of judgement in policy.

For the more recent Evolutionary Approaches to Innovation/Technology. I will refer the reader to the works of Nelson & Winter (1982), Dosi et al op cit, Nelson 1994, Metcalfe (1996), Andersen (1994), Saviotti (1997) among many others. The essence of the Evolutionary Perspective is part and parcel of the SI perspective to ITP e.g. adoption of a *Dynamic Perspective* with explicit consideration of learning—both interactive learning(Lundvall 1985, 1992) and other forms including *Learning about R&D/Innovation*(Teubal 1996.7) From the ‘normative’ side the Evolutionary Perspective has focused on a critique of ‘neoclassical’ market failure and market failure analysis; but- as already mentioned- precious few general principles to guide policy makers have been put forward or put forward in an integrated way(one of them is Metcalfe’s ‘Adaptive Policy Maker’ which I extensively use in the paper; another is Malerba’s discussion of the balance between Exploration and Exploitation). The main problem seems to be that policy has not yet explicitly been considered as process.

2:THE SI PERSPECTIVE TO ITP: BUILDING BLOCKS AND GENERAL PRINCIPLES

A (National) Systems of Innovation perspective to Innovation/Technology is an ‘intermediate’ view concerning the role of market forces versus the State in conducting Innovation/Technology/Economic activities in general. It lies between a ‘pure market’ view of the operation of enterprises (with its emphasis on the individual enterprise facing input and product markets) and a ‘planning or State-led’ model or mode of operation/development. In the SI perspective individual enterprises operate

³ A major “Normative” Neoclassical aspect of this paper is its emphasis on Incentives’ Programs stimulating the Business Sector of Industrialising Economies

within (or are embedded in) a set of institutions and non-firm organisations —a ‘Supporting Structure’ which determines to a large extent both behaviour and outcomes. It is an actor-based system rather than a ‘firm’ (& consumers) based system since active roles can be played also by decision making units within the Supporting Structure. The SI perspective is less a framework for the allocation of resources than one for understanding innovation and innovation-based behaviour of firms and of non-firm organisations.

The SI perspective emphasises the *Collective* nature of the Innovation Process—every entrepreneur is embedded in a set of institutions/ organisations supporting it; and in a particular social structure and culture. Moreover, cooperation between firms and among them and non-firm organisations is not only possible but frequent, probably increasingly so due to enhanced ‘connectiveness’ brought about by Globalisation and the spread of Information Technology.

The basic point as to the way to approach the SI perspective to ITP is to distinguish between general principles & salient aspects of the “Positive” side of the perspective and those of the “Normative” or Policy side. Most of the literature refers to the former. Since “Policy” will not automatically flow from the SI perspective as it is usually presented (with a strong emphasis on ‘Positive’ General Principles) explicit consideration of ‘Normative’ principles is important. This will be the major task of this Section.

2.1 Building Blocks

Component Sub-Systems

For our purposes we will consider a system of innovation as comprising *five (5) subsystems* or *meso-level components*: the business sector (BS); the supporting structure(SS); interactions and links; institutions & markets.; and culture & social structure(Teubal & Andersen 2000)⁴. For lack of space our analysis will emphasise the first three. The distinction between the business sector on the one hand and the supporting structure on the other differs from that proposed by Lipsey and collaborators(e.g Lipsey & Carlaw, op cit). For them, the basic distinction is between technology and the supporting structure, where the latter would include both business

⁴ Strictly speaking it may be necessary to have a fifth component—a pool of skills and labour— characterised by size, variety etc and which may increase or decrease with immigration and other factors. Some aspects of skills and of labour markets may be considered in the present framework, but a fuller discussion of the interaction between ‘people’ and ‘companies’ will be only considered in future work.

firms and other organisations and institutions comprising our ‘supporting structure’. My choice is based on the fact that the Business Sector generates a large and increasing share of GNP and of growth; and on the fact that—in the current era or innovation paradigm—“users” of new technology in this sector must to a large extent develop it themselves. Alternatively, we may say that the Business Sector has a comparative advantage in generating those technological developments that it itself implements. Thus the Business Sector is the “backbone” of the process of SI transformation process.⁵

Business Sector(BS)

The *business sector* is the *backbone* of the system and its *restructuring* is the central axis of the process of transformation of systems of innovation. A Business Sector may have a wider or narrow *set of sectors* and it may have more or less *depth* that is sectors and firms linked among themselves through input/output market transactions. The industrial base of small countries may be narrow⁶; and whenever the BS is heavily dominated by one sector the system of innovation would largely consist of the sectoral system which is specific to that sector⁷.

From a SI transformation perspective full characterisation of the Business Sector would not be complete without considering *the capacity of firms to adapt to the changing internal and external environment they face*. The presumption of enterprise heterogeneity is crucial. There will be “innovators” which may also be called Schumpeterian entrepreneurs, “imitators”, and “laggards”; and the *diffusion of R&D/Innovation (& more generally, of enterprise restructuring)* will proceed in phases, starting with the former group and ending with the latter (Teubal op.cit, Teubal & Andersen op.cit). We may not be able to identify or know a priori which firms belong to each category, in principle sectoral affiliation need not explain the distribution of firms according to their capacity to adapt. However, frequently Start Up companies in hi tech may play the role of Schumpeterian entrepreneurs in this process (Saxenian op. Cit).

⁵ This is consistent with the view that the underlying knowledge and ‘generic technologies’ frequently are created within Universities and other institutions/organisations of the Supporting Structure. The statement about the business sector being involved in the generation of the innovations it uses includes both situations where there is little room—due to transactions costs and other reasons—for independent R&D companies and others where such companies can thrive. See Teece (1986).

⁶ e.g. Israel’s industrial sector is heavily biased towards hi tech industries and has a lower than OECD average weight of other sectors including a significantly narrow set of mid-high tech and low tech industries. See Avnimelech et al (2000).

⁷ For sectoral systems of innovation see Malerba (various articles) and collaborators.

Supporting Structure(SS)

The *supporting structure* involves a number of elements which are quite directly related to the transformation of such systems and more specifically to the restructuring of business enterprises. Thus we would include Technology Centers, Universities, Government Laboratories; and Venture Capital (VC) companies⁸. Needless to say that the borderline between the supporting structure and the wider system is not fixed but depends on the context and on the objectives of the analysis. Nor is the borderline between the business enterprise sector and the supporting structure. absolutely clear and immutable. Thus a Government-owned Venture Capital company would be part of the supporting structure if its objective was to effectively promote companies. But a privatised VC company which was formerly Government owned would in principle be part of the Business Enterprise sector.⁹

Links & Interactions¹⁰

These, which include interactions among actors of a SI, are frequently considered the central elements of a system of innovation, one which distinguishes the systems of innovation perspective from a conventional perspective to the business sector where each firm is considered more or less to be on its own, confronting an impersonal & neoclassical market.

Links are critical for SI and more specifically for clusters and industrial districts. Since interactions are very much associated with learning e.g. within user-producer networks(Lundvall op.cit, Johnson op. Cit.) there seems to be a tendency to state that *non-market links* are the essence of a system of innovation. While not denying the importance of non-market links, well functioning SI also require

⁸ The supporting structure should also include the 'policy subsystem' (Galli and Teubal op. Cit) that is the set of organizations and institutions associated with the design and implementation of ITP. See Saxenian op.cit.

⁹ This illustrates how Business Sector "depth" frequently will provide the support required for BS transformation or restructuring without the need for new elements of the supporting structure(see above story of Silicon Valley's restructuring during the 80s). In this connection a distinction should be made between two types of segments of the business enterprise sector: a segment whose activity *supports* companies through the provision e.g. of specialised services & inputs (a largely *indirect* contribution to growth); and one that does not support such companies and whose contribution to value added is *direct*. The latter would include domestic VC companies whose activities are directed to foreign SU companies. Many Israeli Venture Capital Companies are now establishing themselves in foreign markets(personal communication).

¹⁰ In what follows I will not survey the notion of Institutions. Readers could consult various articles by Nelson and Edquist (ed) op. Cit.; and the survey by Greif (2000). The concept of Institutions is still under flux and two new approaches have recently been proposed (Nelson's social technologies and Greif's integrative analysis). For the purpose of this paper, institutions are 'rules of the game' or the organisations generating/overseeing these rules

significant market links e.g. among firms in different stages of production, strategic partnerships or alliances due to technology or other complementarities; or inter firm links flowing from market-based processes of diffusion of new generic technologies. Moreover, a lot of the non-market interactive learning is related in some way to market links and market transactions(see Lundvall's "organized market").

Any characterisation of the SI links should not ignore the *External Links* of the system particularly when the SI is confronted with a new wave in the Globalization process. These are not only the result of trade. In fact, during the 90s and nowadays when the Silicon Valley phenomena is beginning to diffuse to other regions of the globe, *capital market links* are extremely important¹¹. These are very important factors in the development of software & high tech industry by the Top Tier NIEs.

Focus: Dynamics of BS Restructuring and of SI transformation

For the Systems of Innovation perspective to be relevant to ITP today it should not be primarily interested in the *operation* of an existing system but in its *transformation & transition* to a new system of innovation, presumably more adapted to the new international environment and internal context. By *successful operation* of a SI I mean not a static situation with no growth but rather a virtuous cycle of growth under more or less unchanged external and internal conditions. However the real challenge today is to sustain growth under fundamentally changed external and internal conditions. Most work on SI however deals with operation rather than with transformation of the system(e.g. most Sections in Edquist, op. Cit).

System *transformation* is a *Cumulative Diffusion process fed by Collective Learning and by System Effects*. Learning about restructuring is “collective” especially in the early phases of system of innovation transformation¹². ‘System Effects’ reinforce the effects on cumulativeness of the transformation process; they derive from the activities of new or modified organisations/institutions supporting the Business Sector (BS).

BS restructuring involves both Technological and non-technological factors e.g. new Management Routines, Strategies and Organisational forms. Because such restructuring is required for the business sector to perform its function of generating

¹¹ Teubal et al 2000 on the importance of Initial Public Offerings (IPO) for the growth of very successful software companies in the Data Security area:

¹² Collective learning concerning ‘whom’ and concerning market and technology trends was emphasised by Saxenian in her book on the Silicon Valley hi tech cluster which is a ‘regionally based’ system of innovation. See Saxenian op.cit.

value added under the new context facing the economy; and since it cannot be assured to be automatic--I view it as the *backbone and focus* of the analysis of SI transformation.

2.2 “Positive” General Principles((compact presentation)

The General Principles underpinning a (Dynamic) System of Innovation Perspective to ITP are

- *R&D & learning*
- *New System Components (Elements) & Links*
- *Cumulativeness and Co-evolution*
- *Emergence of New Demands(for New Components and Links, etc)*
- *Fundamental Uncertainty*
- *Role of Capabilities*
- *Firm Heterogeneity and Sector/Technology Specificities*
- *Key Agents*
- *System Embeddedness*
- *Possibility of Lock In*

I will briefly expand on the first five of the above items.

R&D and Learning

The basis of the system of innovation perspective is that both R&D **and** Learning are important, and that there are many types of learning (as well as of R&D) including ‘learning about R&D’ or ‘learning to innovate’(see above and the following boxes, below). It is inconceivable that SI transformation take place without important learning processes , partly ‘collective’, taking place.

<i>INTRAFIRM 'LEARNING ABOUT R&D/INNOVATION'-early 'Innovation Phase' of Countries</i>
1. Learning how to search for Market and Technological Information
2. Learning to identify and generate new projects
3. Learning to screen, evaluate and choose new projects
4. Learn to manage the innovation process(linking Design to Production & Marketing; selection of personnel; budgeting; etc); etc

New Sub-System Components; New Links

When changes in the environment are sharp it is unlikely that the transformation of systems of innovation could be undertaken without fundamental changes in the ‘architecture’ of the system, particularly the incorporation of new elements or components either into the business sector or the ‘Supporting Structure’. Taiwan is a good example where the establishment of Government owned laboratories --a component of the 'Supporting Structure'-- during the beginning of its 'Innovation Phase' (late 70s and 80s) enabled it both to successfully enter the Semiconductor industry *and* to upgrade more traditional industries.¹³ Another example is the appearance of Venture Capital within the Supporting Structure of Israel’s high tech industry during the 90s; and the simultaneous appearance of large numbers of new technologically based start up companies during the 90s. Both represented a radical transformation of the previous 'Electronics Industry' & ‘Electronics’- oriented system of innovation of the 80s in that country¹⁴.

Changed architecture also relates to new links, both domestic links across subsystems (e.g. the reinforcement of University-Industry Links) and international ones. Thus the above-mentioned VC segment was very strongly linked from its onset with US Private Equity Investment Companies and other US organisations. More generally, globalisation raises the importance of new and more varied international

¹³ See the analysis of ITRI (Industrial Technology Research Institute) and one of its laboratories (ERSO-Electronic Research Service Organiation) in Nelson ed (1993), chapter 12 ..

¹⁴ There are other examples of ‘changed architecture’, also concerning ‘sectoral systems of innovation’. R. Nelson & Sampat (1998) describes how the growth and development of the German Chemical industry in the last decades of the 19thC. depended closely on the creation of Chemistry departments at German Universities

links—not only standard product market links, but also links associated with cross border transactions in (or concerning) *assets*.

Cumulativeness & Co-Evolution

A major aspect of the dynamics of transformation is *cumulativeness* that is a process, which when initiated (and due to positive feedback including that from learning) becomes self-reinforcing. This happened in Israel during the 90s. Once the process was triggered by changing external and internal circumstances (peace, immigration, new links with the US e.g. access to NASDAQ) and by policies (the enactment of three major new Government programs directed to VC, entrepreneurship and cooperative R&D) a cumulative process of change took place with success breeding more success. It seems that one critical aspect of this process was interactive learning between start up companies and newly formed Venture Capital companies; another was increasing mutual knowledge of both Israeli and relevant sets of US companies. Thus learning was critical in propelling cumulativeness; but so were changes in the supporting structure namely the timely advent of Venture Capital. Thus cumulativeness should be viewed as the combined effect of collective learning and 'system effects' (Teubal op. Cit.). Cumulativeness could be related to *co-evolution* e.g. between business sector and the supporting institutions/structure (Nelson op cit) or between agents in the Business Sector. Thus the hi tech cluster emerging in Israel during the 90s involved co-evolution between start up companies and Venture Capital (Gelvan & Teubal 1997).¹⁵

Emergence of new "Demands"

An important aspect of SI transformation is *emergence of new demands*-- in our context, demands for the new products/services offered by the supporting structure (e.g. "financial and other services offered by VCs"); demand for new links; and demand for 'restructuring' itself. Coordinated growth of both, supply and demand, is part and parcel of successful transformations (Teubal op. Cit). Demand should be distinguished from "Need"—there may be a Need for the various new elements of the SI but not demand, at least initially.

This view is important for policy, since there cannot be a presumption that demand for the critical new components of the system will be out there or will

¹⁵ Saxenian extensively discusses the collective learning and co-evolutionary processes spearheaded by Sun Microsystems and other companies which were part and parcel of the restructuring of Silicon

automatically appear. Policies—especially those inspired by the ‘linear view of innovation’—have been very biased in the past towards the provision of incentives. They have traditionally not aimed directly at the creation of demand. This should and is changing. We know for example that both Supply and Demand policies might have to be implemented for ‘coordinated growth of supply and demand’ of Venture Capital in Israel. Note that a major mechanism for enhancing ‘demand’ is interactive learning (Teubal op cit).

Fundamental Uncertainty

The basic insight is that Fundamental Uncertainty exists, not only risk that is translatable into ‘states of nature’ and corresponding probabilities. This is related to Metcalfe’s view that the Capitalist System is an open system (Metcalfe 1999) and that the objective of policy is to ‘maintain open conditions’ (Metcalfe 1998).

The implications for theory are clear, we cannot fully ‘model’ reality, the direction of change frequently cannot be predicted; and the basis for true ‘maximisation’ or ‘optimisation’ is not there.. Lipsey & Carlaw op.cit have emphasised this point and its implication for policy, namely, that **an element of judgement** is inevitable (although this judgement may be informed by theory and by data).

2.3 "Normative " General Principles of ITP

Given the multiplicity of SI components and even more of agents or agent types, and the potential complexity of SI transformation a normative perspective should refer to a *set of policies* rather than with individual policies (Edquist op cit, Teubal op. Cit, and Teubal & Andersen op cit). System transformation to be effective requires addressing the whole system rather than individual components. Under these circumstances a successful impact of one program or policy will depend on existence or non existence of other policies; and the total impact of a particular policy will involve a significant ‘indirect’ component.¹⁶ This implies that the policy effort is more complex than what would seem to be the case in a Neoclassical world; and that policy coordination (at a moment of time and through time e.g. in connection with

Valley during the 80s. In the analysis of that period she does not focus, however, on adaptations of the supporting structure.

¹⁶ It also implies that past failure of a particular program may imply, under certain circumstances, that such a policy—together with complementary policies—might have to be reinforced rather than be discontinued.

program sequencing) is an important inter-program aspect of such an effort. Moreover a true system of innovation perspective emphasises rather than glosses over systemic differences among countries. This in turn implies that policies are context specific(Lipsey & Carlaw op cit).

Most of the Normative features or general principles of the System of Innovation perspective to ITP are ‘claims’; and a minority are normative ‘Building Blocks’. They are presented in a single list below.

- *Adaptive Policy Maker*
- *Policy as Judgement*
- *An Explicit Strategy*
- *Policy is Context Specific*
- *A Portfolio of Coordinated Policies*
- *Policy Objectives-Learning and System Transformation*
- *Stimulating Demand for “Critical Components”*
- *Learning in Policy Implementation*
- *Policy Cycle and Program Sequencing*
- *Policy Learning and Policy Capabilities*
- *Mix between Top Down & Bottom Up initiatives*
- *Policy should be Research and Knowledge Intensive*
- *Policy—Business Co-evolution & Policy Lock In*
- *Characteristics of a Country’s ‘Policy Portfolio’*
 - Mix between Institutions &Incentives
 - Focus on both R&D & non-R&D factors
 - Portfolio Profiles and Policy Biases

I now turn briefly to each one of the first ten (10) items; and then briefly to the last.

2.3.1 Adaptive Policy Maker

The existence of fundamental uncertainty led Metcalfe to ascertain that policy makers are adaptive rather than optimisers (Metcalfe op cit.). An optimum allocation of resources’ is difficult to conceive of (Metcalfe op cit); and even if exists it would

be unknown to policy makers.¹⁷ This has an immediate implication for the support of R&D, the cornerstone of the Neoclassical Perspective .

The term ‘Adaptive’ should not be construed to mean ‘incomplete adjustment’; it rather means that neither the direction nor the extent of change can be fully ascertained or determined. Nonetheless, through learning and experimentation; search and research; and through a process of ‘muddling through’--ITP should aim at a successful adaptation of the system of innovation to changed conditions.

2.3.2 Policy as Judgement

Fundamental Uncertainty and the inevitability of Ignorance on the part of policy makers, explains why adapting to changed conditions necessarily involves an *element of judgement* in policy(Lipsey & Carlaw op. Cit.). Despite and probably because of the uncertainty, such judgement should be informed by Theory and Data(Lipsey & Carlaw op.cit). Also it implies the desirability of adopting a Strategic Perspective to policy, one which identify *priorities* for Innovation and Technology (see next point below). Moreover, the inevitability of 'judgement' enhances the importance of new knowledge. *Policy relevant research* (including that performed in Academia) is more important than ever. It should, however, be largely multidisciplinary with a hybrid methodology particularly with respect to the setting of new priorities in response to significant changes in the environment (Teubal op. Cit.; Avnimelech et al op.cit. and Bartzokas & Teubal op.cit.). Such research should recognise its limitations - it should no less ‘inform judgement’ than arrive at well defined prescriptions for action.

The adaptive policy maker will act at the various levels or phases of policy making(see ‘policy process’ below)—strategy formulation, setting priorities, identifying programs and other policy actions. Strategy formulation in particular is fraught with the fundamental uncertainties suggested both by the Metcalfe and the Lipsey analysis.

2.3.3 An Explicit Strategy

While the sequence

Fundamental Uncertainty-→ Adaptive Policy Maker-→ Policy as Judgement

¹⁷ This is why market failure *analysis* as propounded by the neoclassical perspective is not relevant for policy making today. This does not mean that a ‘redefined’ notion of market failure is not useful . It is

is consistent it is not enough to capture the *'problematique'* of policy making since the direction of change in policy, in response to changed circumstances, will not be unambiguous. An *Explicit Strategy* would both establish priorities in certain areas and adopt a 'wait and see' & 'search and experimentation' posture in others. Strategy is justified given the impossibility of applying economic calculus (including risk analysis) to choose among all relevant SI transformation patterns or transition trajectories. Since optimisation cannot be applied policy making should strive a) to generate a small number of alternative future scenarios of the SI; and b) to select one or a very small number, which given the 'informed judgement' of policy makers, seem to be adequate for the country.

A strategic perspective involves at least three elements: a *vision* about the future of the system of innovation; a *strategy* to achieve it; and a set of *priorities* associated with such a strategy. It is not always possible to separate the three.; therefore I shall consider *vision/strategy* on the one hand and *priorities* for Innovation and Technology Policy on the other. These priorities would then be translated into programs, institutional changes and other policy actions e.g. information.

One vision/strategy for many countries in Europe could be a business sector with an undergrowth of start up companies carrying new technologies in the IT area which would facilitate entry into new areas of rapid growth. This would enhance the product innovation component of Europe. In Israel, a reasonable vision/strategy would be different. Beyond assuring the continued flow of SU it would involve a business sector populated by a larger subset of large global companies in IT high tech; a better 'Exploitation' of R&D results more generally speaking; and a thriving biotechnology cluster which may exploit the country's pool of skilled labor in the life sciences.

2.3.4 Policy is Context Specific

This is a central feature of non-neoclassical perspectives. It will be dealt in part with in the 'Policy Environment' subsection (subsection 3.4).

2.3.5 A Portfolio of Coordinated Programs

(Teubal 1998a op cit) although its nature and role differs from those it has within a neoclassical perspective.

One reason why policy is serious business and a complex one as well is the likelihood that SI transformation requires a changing portfolio of policies with internal coordination among policies within the portfolio. For a conceptual ‘model’ both of a ‘successful’ transformation and of the changing policy portfolio underpinning it see Teubal op. Cit and Teubal & Andersen op. Cit. Some salient characteristics of the portfolio of programs are presented below in Chapter 3. The accompanying boxes shows ITP program & policy co-ordination in Israel for the 1980-2000 period. These problems are likely to exist or to arise in other countries as well, both in those countries shifting from an ‘imitation’ to an ‘innovation’ phase and for top tier non-advanced countries facing the current winds of globalisation as pertains to high tech development.

COORDINATION OF PROGRAMS & POLICIES-ISRAEL 1980-2000
1.Support for Business Sector R&D should be coordinated with the supply of high level R&D personnel –engineers, scientists, technicians. Non-coordination may cause R&D support to exacerbate R&D personnel shortages(depending on the institutional context). It may also lead to a rise in compensation rather than to ‘increases in real R&D performed’ (no-additionality).
2. Support for Business Sector R&D should be re-assessed and re-configured in light of increasingly dominant role which Venture Capital plays in financing Start Up companies(e.g. 3.4 B\$ raised during 2000). Venture Capital emerged in 1993 as a direct result of a 'targeted' Government program--"Yozma". Both types of finance are increasingly substitutes rather than being complementary (there seems to have been strong complementarities during the first phase of growth of the Venture Capital Industry); and the marginal contribution of Government subsidies seems to be declining.
3. Enhanced importance of Institutional Changes (e.g. Corporate Law/Governance, De-regulation of Telecommunications; Competition Policy, etc); of General Incentives e.g. Capital Gains Taxation; and of other policies (e.g. Strategy of the National Telecoms Company and the process of its privatisation). Given that better institutions reduce the ‘need’ for Business Sector R&D support., changes in both institutions and in incentives must be coordinated

2.3.6 IT Policy Objectives: Learning and SI Transformation

Whatever the strategy adopted in terms of the likely contours of the future SI (one reflecting a good 'fit' with the changed or changing environment facing the country) etc, the overarching objective of ITP would be to facilitate a transition to such a system. This would generally mean achieving Cumulativeness (or Dynamic Economies) in Business Sector restructuring and in the co-evolution between it and the Supporting Structure. A major component of cumulativeness is Learning. Business Sector Restructuring-- both enhanced R&D/Innovation and changes in Strategy/Organisation-- *without learning, (including collective learning) would rarely suffice.*

2.3.7 Stimulating Demand for "Critical Components"

Traditionally the major role of policy was to create supply incentives e.g. to reduce enterprise costs of doing R&D, but gradually this was superseded by a more mixed perspective where both demand and supply stimulation was aimed at. This links with the learning processes occurring during SI transformation. For example the 'learning to do R&D/innovate' that flows from implementation of Horizontal Programs (see below) has a dual effect—first, it reduces cost & enhances the efficiency of R&D; second—it enhances the 'demand' for R&D by business enterprises. (Teubal op cit). Similarly with respect to new components of the BS Supporting Structure which may be considered as critical for SI transformation: policies which are directed to stimulate their appearance or emergence must be designed with the view that a) the bottleneck to emergence of such an element may be lack of demand rather than issues of cost/efficiency in supply; b) success may well require enhanced demand as well as lower cost/increased efficiency in supply.¹⁸

<p style="text-align: center;">WAYS OF STIMULATING <u>DEMAND</u> FOR VENTURE CAPITAL (ISRAEL, 1990s)¹⁹</p>
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¹⁸ It is important to emphasise the link between learning or interactive learning on the one hand and "demand" for critical elements or components of SI transformation. Frequently one gets the impression from the literature that 'Demand side policies' are circumscribed to "Government Procurement"

¹⁹ Other countries have traditionally followed supply incentives policies (European countries till at least the mid 90s)—and with little success. Since the moneys involved at least in the early phase of

1. A pre-existing Horizontal R&D Support Program (the “Industrial R&D Fund”) which supports R&D throughout the Business Sector. This enhances the flow of SU (‘demanders’ of VC services) ²⁰
2. Implementation of the Technological Incubators Program
3. The conditions of operation of 'Yozma'-a Government owned VC company created in 1993 to invest in private VC funds- involved partnerships with experienced foreign Investment Banks/Financial Institutions. This created the opportunity of 'learning from others' and better 'interactive learning' among local agents. Thus a measure of 'market building' was built -in into the program.

2.3.8 The Learning Approach to Program Implementation

There are a number of elements pertaining to implementation of specific incentives' programs (including ‘creation of demand’) given that learning and SI transformation objective mentioned above. From a study of Horizontal programs these would include

- Assuring a Critical Mass of Projects as early as possible during the Infant Phase of the program
- Creating a Policy Implementation Network—to assure learning by experience on the part of policy makers
- Generating Policy- relevant typologies of R&D projects/Innovations, firms and areas
- Analysing, codifying and diffusing knowledge about the Learning & Growth Processes of successful companies
- Special Attention to promote *wide diffusion* of R&D (or other relevant activity promoted) during the mature phase of program implementation(including actions to avoid biases against SMEs)
- Explicit attention to developing Policy Capabilities
- Other: flexible budgets, use of grants rather than loans, bottom-up determination of projects, etc

These factors have been analysed in Teubal op cit in the context of Horizontal programs. None of these factors can be assumed to be given, on the contrary—many would go contrary to the intuitions and to the routines of policymakers.

development of the industry are small the major reason for non(or limited) success would seem to have been failure to generate demand. A second problem might have been, as far as IT high tech is concerned, absence of support of new "international links" between local and foreign (e.g. Silicon Valley) agents.

At the individual program level, proof of success in the adoption of a ‘learning approach’ to implementation, would be *program take-off* i.e a situation where the number of new projects applying for support increases fast and eventually outstrips the possibilities of support.²¹ Under favourable conditions take off may happen a few years after initiation of program implementation Two other indicators of success are ‘*endogenization*’ of the activity supported (e.g. R&D in an Horizontal Program); and achieving ‘*wide diffusion*’ of such activity. The former would mean that an increasing number of projects would be implemented even without (or with reduced) Government Support.²² Achieving wide diffusion, in my opinion, should at least substitute in part the objective of achieving a suitable rate of return on Government disbursements supporting the activity (this means that the ‘return’ would have a qualitative component—wide diffusion of a strategically important activity within the business sector- and a quantitative one- measured rate of return). Achieving all three objectives would be indicative of the cumulative, learning-induced process mentioned above.

LEARNING DURING THE IMPLEMENTATION OF A SPECIFIC PROGRAM: ISRAEL DURING THE 1970’s and 1980s(the “Industrial R&D Fund”)
Firms learned about the importance of Marketing (overcoming the previously held view that “my invention is so good that it will sell automatically”)
Officials and experts of the Office of the Chief Scientist(the Agency in charge of ITP) learned, partly through exchange of information within an informal ‘policy network’, a) to assess the quality and the potential of projects submitted; b) how to help firms configure such ‘projects’
Firms acquired capabilities for identifying new projects, including “complex” projects which build upon prior “simple” projects

2.3.9 Policy Cycle and Program Sequencing

Application of a systems/evolutionary perspective to the implementation of a specific incentives program leads, in response to collective learning and to the generation of new institutions/organisations serving the system, to a Technology Policy Cycle with Infant and Mature Phases. This parallels the Fluid and Rigid Phases of the Innovation/Product Cycle. This has been investigated systematically in a series

²⁰ The timely restructuring of Military Industries in the mid and second half of the 80s increased the flow of engineers and other R&D personnel which could make use of this R&D support scheme. This was one reason why an ‘excess demand’ for VC services apparently existed in the early 90s.

²¹ This might but need not coincide with the point of inflexion of the S-curve used in Diffusion Studies.

²² The ‘additionality’ test justifying Government support to R&D would not succeed. In Neoclassical parlance ‘market failure’ would have disappeared.

of articles dealing with Horizontal Technology Policies(Teubal op. cit) that is policies oriented to the business sector as a whole (rather than to a specific sector or technology) with a strong neutrality of incentives component, especially in the Infant Phase of implementation of the program.

TECHNOLOGY POLICY CYCLE: DYNAMICS OF LEARNING & MARKET FAILURE; AND IMPLICATONS FOR INCENTIVES(INFANT AND MATURE PHASES)
<i>Stylised Situation at the Beginning of the Infant Phase</i>
1. <i>Pervasive Learning Externalities ('everybody learns from everybody')</i>
2. <i>Ignorance of Policy Makers (about location of most important Market Failures)</i>
Implication: Neutrality of Incentives
<i>Dynamic/Learning Effects and their impact during the Mature Phase</i>
1. <i>Exhaustion of some types of learning (and associated externalities)—those associated with the emergence of a class of 'routine' projects</i>
2. <i>New Opportunities for 'complex projects' and for programs promoting other technological activities e.g. generic, co-operative R&D</i>
3. <i>Enhanced Knowledge of Policy Makers</i>
Implication: Greater Selectivity in Incentives; and desirability of implementing new programs, either Horizontal, or Targeted or both.

The above is an 'ideal' analysis of the Technology Policy Cycle: it is seldom applied fully in most contexts. Note that implementation according to the model leads to a measure of *program sequencing* i.e. success in the original program will create new opportunities for successfully implementing new program. In Israel successful implementation of the 'backbone' "Industrial R&D Fund" (since 1969) led--20 year later--to three new programs: Yozma (in support of Venture Capital, during 1993-7), The Magnet Program(support of cooperative, generic R&D, since 1992); and the Technological Incubators Program. This program sequencing reflects both 'policy learning' and a changed internal and external environment e.g. the Oslo Peace Agreement, Russian Immigration, etc

2.3.10 Policy Learning and Policy Capabilities

<u>POLICY LEARNING—ISRAEL</u>
Underlying the spate of new programs of the early 90s was a measure of both Experienced-Based Learning & research–induced Knowledge Acquisition
<i>1) Policy- learning underlying Yozma:</i> The high rate of failure of high tech Start Up companies during the late 80s led to a search for means to solve the problem. It was found in a new financial institution prevalent in Silicon Valley—Venture Capital. The Chief Scientist, Ygal Erlich, considered alternative ways of stimulating Venture Capital. Some were implemented (the <i>Inbal & Yozma programs</i>); and Yozma was particularly successful
<i>2) Policy-learning underling the Magnet Program:</i> The consolidation of R&D/Innovation Capabilities in Israel during the first 20 years of implementation of the “Industrial R&D Fund” created new opportunities for the promotion of Cooperative, Generic R&D. A systematic effort of assessing the “Strategic Need”, of creating awareness, and of probing for alternative designs for the future program was undertaken by Academics at an independent policy-research institution(The Jerusalem Institute).Policy makers both at the Treasury and at the Office of the Chief Scientist ‘learned’ about this proposal, and approved its implementation in 1992.

2.3.11 Salient Characteristics of the ‘Policy Portfolio’

Mix Between Incentives and Institutions: The view that ‘institutions are paramount’(Edquist op.cit) seems sometimes to be taken to mean that there is no role for incentives in ITP directed to SI transformation²³. This is not warranted despite the fact that in some contexts incentives could be largely ignored. Incentives e.g. R&D grants, conditional loans, or general tax policies may potentially play very important roles in system of innovation transformation. Moreover, incentives today could complement institutions today and may help generate patterns of behaviour that eliminate or reduce the need for incentives tomorrow

Focus on R&D and non-R&D Factors: Enhanced R&D impact and enhanced Innovation during SI transformation in an era of globalisation require explicit

attention to non-R&D factors such as organisation & management, marketing & production, and to institutions & other factors leading to the growth and consolidation of innovative companies beyond the R&D phase. Frequently an ITP policy focusing only on R&D (the focus of the Neoclassical Perspective) would generate relatively little economy- wide impact due to large numbers of failures in the commercialisation of the outputs of supported projects. Related to this fact is the realisation that support of R&D (as in Israel and other countries) rather than support of Innovation as a whole reinforces the inherent technical biases of many technological entrepreneurs (see Avnimelech et al op cit for some instances of this in Israel)²⁴

3. APPLYING GENERAL PRINCIPLES

3.1 Vision/Strategy and Policy Process

I have already mentioned that application of General ITP Principles to concrete policy situations cannot be direct nor automatic. It requires not only familiarity with the specific setting within which the policy should operate, but also additional theoretical and practical ‘knowledge’--about *policy phases/process* and the country's *policy environment*.

This section aims at providing a modest beginning to the additional ‘knowledge inputs’ required. The starting point is to view ITP as a *process* with *distinct phases and activities*- a view that parallels the view of Innovation itself as a process(See Kline & Rosenberg itself). We have already mentioned a Strategic dimension which when activated ends up with a new set of country priorities for Innovation & Technology (and the Business Sector as a whole). *Upstream Phases* include generation of a Vision about the future SI, of a Strategy to achieve it, and translating Vision/Strategy into a Set of Priorities (Teubal op.cit). The policy process's *Downstream Phases* include Identification of acceptable Program Portfolio Profile (PPP) & Institutional Changes for the country which would advance the above-mentioned set of priorities, Program Design, ²⁵Program Implementation and Impact Assessment & Feedback(Table 1). The feedback from program assessment

²³ The reasons are not clear but the fact is that beyond “procurement policies” there has been very little consideration of incentives within the SI perspective (see Edquist op. Cit).

²⁴ A balanced between R&D and non-R&D factors would seem to be even more important for an economy linked to world asset and capital markets.

²⁵ Program design would involve the identification of the activity to be promoted; the Business Sector focus; the program's company (or SS-organisation) orientation; the tools to be used (subsidies, conditional loans, etc); the effective incentive rate; and the criteria for project approval.

may influence both priorities and specific program design, that is either upstream and/or downstream phases of the policy process.²⁶

TABLE 1: POLICY PROCESS-PHASES (BS-directed Incentives' Programs)

PHASE	OBJECTIVE	TASKS-ACTIVITY	OUTCOME
1. Upstream- Strategy Formulation	Formulate an Explicit Strategy	Search, Research & Interaction(stakeholders & experts), generating a Vision/Strategy	Set of (new) Priorities in Innovation, Technology and for the Business Sector
2.Downstream- Determining the Program Portfolio	Identifying an adequate Program Portfolio <i>Profile(PPP)</i>	Evaluation of alternative Program Profiles and Mixes of Programs; Preliminary Design; Trial Implementation, Final Design	Determining a (new) Set of Programs & Program Designs which “fit” Priorities
3.Downstream- Individual Program design and Implementation; Assessment	Successful Implementation and Learning	Full Implementation; operational adjustments; research on impacts and on Success/Failure.	Contribution to Business Sector Restructuring; New Information about ‘Policy Needs’

The basis for initiating upstream phases is an *understanding of the trends in world markets, technology and competition*; and the *implications of this for the country in*

²⁶ The above view of the policy process further develops the one put out in Teubal op cit.. It differs from that put forth by Edquist (Edquist Op.cit) despite some correspondence between his categories and mine. His “problems” come close to my “strategic priorities” although there is little discussion of the various levels of specificity in the formulation of ‘problems’(I recognise that this is difficult and no good solution has yet been arrived at). A second point concerns the transition from ‘problems’ to policies: while Edquist makes it depend on the political system with very little further specification, the framework presented here tries to flesh out some of the elements of the process (e.g. a typology of policy processes, link with the policy environment, etc—see later). This approach could shed light on the interactions between the professional aspects of policy and the political ones.

question (Bartzokas & Teubal op cit).²⁷ Thus the shift to the Internet and to the New Economy, and the associated globalisation of asset and capital markets, may create numerous new opportunities for certain countries and not others, and then only for those who succeed in implementing a new set of programs and policies. An explicit Strategy may lead –in some countries --to a reconsideration of priorities in the direction of SU formation and VC(Korea and several countries in the EU); and in other countries it would lead to a renewed emphasis on indigenous, global company formation(Israel).²⁸ Whatever the final outcome of an explicit strategy it is clear that identifying the implications of the above-mentioned trends for the national economy requires significant additions to knowledge. In my opinion, collecting information is not enough, it is important to generate conceptual theory for integrating it into a coherent whole. This means that Academic research may have to play a role, side by side with data collection and commissioning work to consultancies.²⁹

An Integrated Policy Process

An ‘Integrated’ policy process involves upstream and downstream phases starting with a new vision/strategy; and almost inevitably-- to new ITP priorities. It is triggered by radical changes in the environment facing the country (including its internal environment).The new priorities in turn would lead to policy activity in Downstream Phases which process leads to *a new portfolio of policies* (PPP, & institutions). The new PPP will generally involve a subset of new programs, the deletion of some old programs; and changes in the design / implementation of some of the remaining programs.

3.2 “Reference” Program Portfolio Profiles (PPP) Based on a Typology of Programs

²⁷ This paper will not analyse in depth the Upstream Phases of ITP. Suffice to say at this point that a number of methods should be implemented such as Foresight and Prospective Studies, International Comparisons, Benchmarking exercises, etc. The Vision, Strategy and Priorities arrived at will also be influenced by Theory, Data and inevitably, Judgement.

²⁸ As mentioned for the case of Israel a well functioning hi tech cluster may require a larger dose not of Start Ups (of which it has plenty) but of larger, global companies since it is believed that this could ensure the ‘leveraging’ of R&D in terms of value added and employment—both direct and indirect effects of R&D/SU & other "spillovers" to the national economy. For Israel we could identify two alternative Vision/Strategies I & II. In I BS R&D is the strategic priority; and little or no explicitness about almost everything else in the system. Under II High Tech is assigned a leading role, but it also strives for a balance with mid/low tech and between the support (direct or indirect) of R&D and non-R&D factors.

The next step in applying ITP General Principles is to identify a reasonable, acceptable and strategy-friendly Program Portfolio Profile for the country. This is not simply a list of programs—the term *profile* is supposed to indicate something about *structure or mix of programs of different types*. It suggests the need of a typology of programs for representing different PPPs. Beyond the PPP concept itself I will introduce two *Reference PPPs* to facilitate the subsequent analysis of a country's PPP-Bias(Sub-section 3.3 below). This procedure points out the way for 'changing' the actual PPP in the 'right' direction.³⁰

3.2.1 A Typology of Incentives' Programs

A major issue in ITP as a body of knowledge concerns the typology of incentives' programs, of institutional changes, and of other policy actions. Existing work on ITP following the SI perspectives is weak in this respect there being very little awareness that this is a crucial aspect of the knowledge base underlying policy³¹. While Edquist's latest work is useful and instructive, on this point he is very vague. His point of view is that policies are “selective” which is true but which does not carry us very far.³² Due to historical reasons and to lack of background knowledge I will here focus on the typology of ‘incentives’ programs rather than that of institutions or institutional changes. Programs should **first** be classified according to their direct impact within SI structure. We thus have programs directed to one or more of the two subsystems--Business Sector or Supporting Structure(*Primary Classification*); or programs directed to System Links/Interactions; to Institutions & Markets or to Culture & Social Structure(*Secondary Classification*). For lack of space I will be considering here only the first group.

Primary Classification

A distinction is made here according to *specific subsystem focus*, namely whether the program is directed to the Business Sector or whether it is directed to the

²⁹ A major bottleneck in commissioning such research and conceptual work is the capacity of the policy making institutions to define objectives and to assess the true capabilities and the true outputs proposed by the organisations competing for the work.

³⁰ While this is not a fully operational method, it--together with the accompanying illustrations--represents a framework which policy makers can use as a starting point in their search for an 'appropriate' PPP.

³¹ As mentioned, the underlying reason would seem to be that ‘policy’ is not really regarded as a field of knowledge in itself, but basically as “application”.

³² I mentioned that selectivity exists not only in Targeted programs but also in both the design and in the implementation of Horizontal programs. For a summary of some of the issues see Lall & Teubal 1998.

BS's Supporting Structure(Justman & Teubal op cit). Programs directed to the Business Sector Subsystem can be classified according to--

- *The (Supported) Activity & its Characteristics(e.g. Breadth)* e.g.'classical' or 'generic' R&D; Transfer/Absortion and/or Diffusion of Technology; a narrow activity like Design or a broad one like 'Technological Modernization'; etc
- *Scope of BS Support-Horizontal Programs*-the whole BS; *or Targeted*-to a specific Sector, Technology or Region
- *Company Focus*: Possibilities-- focus on National Champions; focus on large or small companies; focus on incumbent companies or on SU; focus on Innovative/Schumpeterian or on Laggard companies; etc
 - *Link Emphasis*: whether or not programs directed to the BS indirectly favour *Links and/or Interactions* among or within Subsystems, or between Domestic and Foreign Agents.

A roughly similar distinctions could be made in relation to programs directed to the Supporting Structure.³³

Horizontal versus Targeted Programs

For programs directed to the Business Sector, the notion of Horizontal program must involve 1) a *sufficiently wide scope of BS support & Company focus* of the program (e.g. the whole business sector rather than a single industry; a wide enterprise orientation rather than only directed to e.g. to National Champions); *and* ii) support of a '*wide-breadth*' activity. Thus, while support of 'classical' R&D throughout the business sector could be considered 'horizontal' such a term would be inappropriate to a program supporting 'classical R&D involving Co-operation between Israeli & US companies'. Despite the latter's orientation to the business sector as a whole, the breadth of R&D supported by the program is quite narrow so it might be inappropriate to term it "Horizontal"³⁴. *Targeted programs* as far as the business sector is concerned can be directed either to a specific BS branch or

³³ For example, instead of Scope of BS Support we should refer to Scope of SS Support; and rather than Company Focus we should refer to SS Organisation focus. Note that Targeted Programs directed to the SS can be interpreted in two ways a) exclusive support of 'targeted' technologies and of the SS-organisations housing them; or b) support of only those SS-organisations which facilitate or induce R&D/innovation in 'targeted' BS branches

³⁴ Such a program would in effect 'target' specific links between the Israeli and US Systems of Innovation

technology or to a specific region; to specific links; to a small group of companies; or involve a narrow activity being promoted (e.g. Design or TQM even if it is directed to the BS as a whole). The following box briefly summarises the advantages and disadvantages of Horizontal & Targeted programs.

HORIZONTAL VERSUS TARGETED PROGRAMS-ADVANTAGES/DISADVANTAGES
<i>HORIZONTAL PROGRAMS</i>
1. Since there is no need to identify priority sectors, these programs are implementable without strong initial policy capabilities--as long as the Government Agency has a disposition and a capability to learn
2. Can effectively promote unpredictable, random "variety" in the Business Sector—an increasingly important component of successful growth and evolution
3. Frequently they represent an important component of policies directed to Business Sector Restructuring (promotion of R&D/Innovation & of Organizational Change) since there is a strong Strategic Need in a number of contexts: NIC's opening up, peripheral countries of Europe including Eastern European countries, support of SMEs and of Start Ups, and Advanced countries wishing to promote sophisticated forms of R&D cooperation, etc
<i>TARGETED PROGRAMS.</i> ³⁵
1. Promote 'systemic' variety into the economy
2. Required in the presence of strong sectoral/ technology specificities
3. Feasible when there are clear sectoral or technology priorities which are known or are easily identifiable by policy makers

Horizontal and Targeted programs may be implemented for direct support of the *Supporting Structure* i.e. indirect support of the BS. An example of a ‘Technological Infrastructure Policy’ program which is Horizontal is Israel’s Magnet

³⁵ The theory of Horizontal Programs allows for the possibility, due to learning and cumulateness, that horizontal programs may evolve, becoming more selective in their incentives and even lead to new targeted programs(Teubal op. Cit).

program which operates since 1992³⁶. Taiwan's support of SC technology during the early 80s would be an example of a *Targeted* program (or set of programs and other policy actions) directed to a segment of the Support Structure /Technological Infrastructure supporting a particular technology and/or industrial sector. Other examples are the promotion of IT or biotechnology within Government Laboratories and Universities, or "targeted" support for Technology Centers belonging to priority industries. In some cases Targeted support of Innovation and Technology may be part of a coordinated set of programs and policies directed to generate comparative advantages in certain industries.³⁷

The following box gives some information on the backbone of Israel's ITP which is an Horizontal program supporting BS R&D.

<u>ISRAEL'S BACKBONE R&D SUPPORT PROGRAM—THE HORIZONTAL "INDUSTRIAL R&D FUND"</u>
1. <i>Started in 1969 as a 'pure Grants scheme' and proceeded gradually, as royalties on sales were implemented, to 'conditional loan' status.</i>
2. <i>It has been the 'backbone' of ITP in Israel both quantitatively and in terms of its indirect impact on the emergence of other programs.</i>
3. <i>Formal 'Neutrality' of Incentives--all projects received a 50% R&D subsidy(during most of the period)</i>
3. <i>It was (practically) the only ITP incentives' scheme till the early 90s</i>
4. <i>Total disbursements (net of royalties) peaked in 1997 to approx. 294 M\$. Real reductions have occurred since</i>
5. <i>Venture Capital during the second half of the 90s have increasingly substituted for R&D Grants</i>

³⁶ This program is primarily directed to the business sector although not to individual companies per se, since it supports *consortia involving two or more companies and at least one Academic Institution*. In this sense it might be viewed as stimulating the Supporting Structure rather than Business Firms. Another interpretation is that this program supports the BS directly rather than the Supporting Structure (this is probably a more precise description of reality). The case illustrate the blurred boundary separating the two main SI subsystems- BS and SS. For the notion of Technological Infrastructure Policy see Tassey (1991), (Justman and Teubal 1995), Tassey (1992) and Teubal et al (1996).

³⁷ The Taiwanese example involved support of C-MOS technology absorption and development through ERSO (Electronics Research Service Organization) during the late seventies and early eighties. This in turn led to the development of that country's impressive SC industry. For a summary of Taiwan's policies towards the Semiconductor industry, see Mathews (1997).

3.2.2 'Reference' Program Portfolio Profiles

A country's **(Program) Portfolio Profile (PPP)** refers to the composition of its program portfolio and to the characteristics of the associated program set. Two major profiles come to mind: **PPP 1** which directly focuses on the Business Sector through implementation of (mostly) Horizontal Programs or a mix of programs, with relatively few incentives given to the supporting structure. **PPP 2** on the other hand provides incentives to the Supporting Structure (**indirect** support of the BS) through use of Targeted programs which support only institutions/organisations related to a narrow group of business sectors. Each one of these might have variants of their own depending on specific circumstances and depending on other factors such as the particular activities emphasised. We may have two extreme types of *activity emphasis*: *R&D Orientation* and *Diffusion Orientation*. Thus **PPP 1** may be either R&D oriented (variant 1a) or Diffusion Oriented (variant 1b). This distinction could also be relevant in relation to **PPP 2**. Thus 2b may be relevant for industrialising countries or for countries in the 'Imitation' Phase; while 2a (R&D orientation) would be relevant for advanced countries. The outcome is summarised in the following scheme.

Program Portfolio Profile (PPP)	Sub-system focus	Type of Program	Type of Activity
PPP 1	Business Sector (BS)	Horizontal (direct support of all sectors and technologies)	1a: R&D oriented 1b: Diffusion oriented
PPP 2	Supporting Structure (SS)	Targeted (indirect support of a specific sector or technology)	2a: R&D oriented 2b: Diffusion oriented

3.3 Ascertaining PPP Bias and some Illustrations

3.3.1 Portfolio Bias and the Role of Strategy

I distinguish between *Subsystem Bias* (favouring the BS or the SS); *Company Focus Bias* (Large versus Small; Incumbent versus Start Up, etc); and a *Specific Sector Bias* (e.g. within BS support, a bias favouring High Tech). Other biases could be identified as well. In estimating PPP Bias there are two alternative approaches- the *Neoclassical* and the *SI approach*. For estimating 'High Tech Bias' for example, the Neoclassical Approach would compare 'optimum' relative producer prices (of high tech versus non high tech goods— Q^*) with the relative price ratio determined by the *actual* PPP (Q^+). A PPP pro- high tech bias would mean that $Q^+ - Q^* > 0$. Assessing the bias with this approach would require the policy maker to estimate both Q^* and Q^+ . Given the nature of the economic system (see previous section) Q^* either does not exist or cannot be calculated. Q^+ might in principle be estimated but its value will not be unique—since it depends on the particular set of 'institutions' implemented in the economy at that moment of time. Thus even if the Q^*, Q^+ gap could be calculated (which it cannot except in very special and unrealistic circumstances) we would get a set of values rather than a unique value. The upshot is that the *Neoclassical Approach* to estimating the *PPP Bias* would also require ascertaining the 'optimal' country institutional set up.

The alternative and more realistic approach to determine the PPP Bias of a country would involve two stages a) *identify a reasonable/acceptable Strategy* and associated priorities; b) *determine the "Fit" between Strategy and actual PPP*. Strategy will depend among other things on the stage of development of the country. Thus, under the SI perspective, a country PPP 1a would not or would reflect a bias towards R&D depending on whether or not the 'reasonable/acceptable strategy' involves or does not involve overwhelming support of R&D over diffusion.

3.3.2 Illustrations of Country PPP and of PPP Bias: Imitation Phase(Korea, Indonesia)

This paper does not fully analyse nor does it give the full set of tools for analysing the PPP Bias of particular countries since this would require a much greater *Knowledge Base* than what is currently available.³⁸ My objective here is more modest: to present some typical program/policy portfolio profiles for two phases of growth of

³⁸ Missing elements of the required Knowledge Base include e.g. a Country Typology based both on Phases of Development/Growth and on other factors such as Size, Historical Period, Geographical Location, etc.

countries: the Imitation Phase –where the developing country focuses on absorbing foreign technology and in building the basic Science, Technology and Innovation institutional set up(e.g. Korea, 1982-1980, see Lee 2000 and Kim 1997); and the Innovation Phase(e.g Korea 1980-1997; and Israel 1970-1990) where the focus is on empowering the Business Sector and on Business Sector R&D. While these profiles I believe contain interesting information which other countries may use, in themselves they are not ‘acceptable/reasonable’ PPP for all countries. The purpose of presenting them (particularly the profiles of successful countries and of seemingly successful examples of ITP) is two-fold: first, to establish a basis for comparison with other less successful cases from which a series of policy-relevant questions could be asked; and in some extreme cases, to point out what would seem to be severe ‘biases’ in the policy portfolios of those less successful cases.

For the imitation phase I consider two extreme cases of program portfolio profiles--Korea (Lee 2000) and Indonesia (Dodgeson 2000). It is assumed that the Strategic Priority is to build manufacturing industry through an explicit policy of transferring and absorbing technology from abroad. It is also recognised that, due to the weakness of the business enterprise sector during that phase of development, that a measure of ‘supply push’; ‘top down’ and SS-oriented policies is inevitable. A PPP reflecting this features 'with moderation' could be considered 'balanced' or adequate for a typical country in this phase.

POLICIES & PPP: KOREA(IMITATION PHASE 1962-80)
1. Creation and support of basic Science and Technology institutions(KIST, MOST,GRI)
2. Support of Technological Infrastructure through a network of Government Research Institutes (GRI). These and the other institutions also attracted Korean Scientists and Engineers working abroad
3. <i>Presumed relative absence</i> of direct, horizontal support of technological transfer/absortion in the Business Sector ³⁹
4. Targeted support of industries; restrictive DFI policies and relatively lenient policies as far as licence purchases by domestic companies are concerned

³⁹ The statement cannot be made with certainty due to lack of detailed information of Korea’s incentives’ schemes of that period.

(Presumed) Balanced PPP: an emphasis towards the ‘Supporting Structure’ (technological infrastructure) which seems to be justified. There probably was an excessive amount of ‘targeted’ direct support of the ‘Business Sector’.

POLICY AND PPP: INDONESIA (IMITATION PHASE)

1. Extreme Targeting favouring one sector(Aircraft Industry) and even one firm/National Champion(IPTN-a Government owned company)

2. No systematic policies promoting the Transfer/Absorption of Technology (and Diffusion Policies) oriented to the Business Sector as a whole

3. Weak support of human resource development.

A clearly Biased PPP:

- **no systemic promotion of the SS (including human resources)**
- **absence of broad based direct support of the Business Sector(excepting Aircraft industry)**
- **bias against Technology Transfer & Diffusion Policies**

3.3.3 PPP Bias-Illustrations in the Innovation Phase (Korea, Israel, Argentina)

I assume that a major strategic priority for ITP is the introduction and diffusion of R&D and Technological Innovation within the Business Sector; and this objective would ideally imply strong direct support to business enterprises. A PPP reflecting this and which also does not ignore the other branches of the BS could be considered 'balanced' or adequate for a typical country at this phase in its development.

a)Korea (1980-1997)

KOREA’S PPP-‘INNOVATION PHASE’(1980-1997)

1. *Direct Support of R&D/Innovation at Business Enterprises(through horizontal and probably targeted programs providing tax incentives to R&D; tax credits for human capital development, loans for technological development etc)*

2. *Targeted Infrastructural Support of industrial technologies of strategic importance (including the HAN project)—a component of the Supporting Structure*

3. *Targeted support of Venture Capital(and/or other mechanisms of financial support for R&D/Innovation of enterprises*

<p>A Balanced PPP- involving substantial direct, (presumably) horizontal support to R&D/innovation at business enterprises; and targeted support of relevant components of the ‘Supporting Structure’</p>
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b)Israel(1970-90)

ISRAEL’S PPP-INNOVATION PHASE (1970-1990)
<i>1. Strong, consistent R&D Support of the BS(use of grants/conditional loans)</i>
<i>2. Bias against the Supporting Structure</i>
<i>3.Bias against Mid/Low Tech Industry</i>
<i>A Balanced PPP--with respect to priority of developing high tech industry; a somewhat biased PPP from the overall economy perspective</i>

Comments: Israel’s high level of consistent support for Business Sector R&D during 20 years and its success in generating (towards the end of the 80s) strong increases in Business Sector R&D expenditures is a reflection a Program Portfolio Profile with a clear Business Sector focus. Its weak performance in diffusion of technological development (including R&D) within mid/low tech industry is a reflection both of its Type of Activity focus—R&D—and of its **bias** against those elements of the Supporting Structure most oriented to mid/low tech. e.g. sector specific Technological Centers.

c)Argentina (1990s)

ARGENTINA’S PPP: PROBLEMS IN ITS ‘INNOVATION PHASE’(early 90s)
<i>1. Extremely weak direct support of BS(both in R&D and in other technological development support); unsuccessful attempt at using loans</i>
<i>2. A targeted Industrial Policy program favouring the Automobile Industry</i>
<i>3. Lopsided & distorted support of the SS</i>
<i>PPP: Bias Against Direct Support of Business Enterprises & Distorted Promotion of the Supporting Structure</i>

Comments: Argentina’s lukewarm direct support of R&D/Technological Development in the Business Sector coupled with a rather inefficient allocation of

funds within the Supporting Structure **has not led** to significant introduction & diffusion of R&D/ Technological Development in Firms. Failure to achieve achieve the Strategic Objective reflects, among other things, a **strong Bias** against Direct Support of the Business Sector.

3.4 Towards an "Integrated Policy Process". Role of the Policy Environment

The goal of policy making is to ensure adoption by the country of a reasonable & acceptable PPP. Sometimes this is relatively easy since no fundamental changes in the policy process and in policy making 'routines' are required. In other contexts it may be difficult due to the need of inducing a shift in the way the formulation and implementation of policy is done. In this latter case particularly, policy making should consider what could be termed the "Policy Environment" of the country.

I consider the case where, contrary to past procedures, '*rethinking ITP priorities*' is a necessary condition for identifying a 'new', appropriate PPP. In other words, the Policy Process should shift to an *Integrated Mode*.(p.26). This situation is not an infrequent one. It will arise for example in the transition from the imitation to the innovation phase of a country's development, or whenever radical changes or shocks in the external environment(such as the onset of the current phase in the globalisation process)occur⁴⁰. Note that such a policy process shift is not automatic since, among other things, the conditions assuring such a shift are not well understood. Frequently the policy process will become *trunkated* or *locked-in* in the old mode.

A successful transition to the integrated mode of policy making will require significant amounts of information and probably new institutions of policy such as an 'interactive stakeholder forum' etc depending on each case. I assume that at least one such institution exists--a '*National ITP Committee*' (NITPC) with awareness of the need to change the policy making mode as a pre-condition for arriving at a new, appropriate PPP; and with a level of authority and capabilities which, while not assuring success in the endeavour , makes it worthwhile to make a significant attempt. The NITPC will have to take into account the specific Policy Environment of the country.

⁴⁰ Moreover there are limits to the possibility of 'stationary conditions' as far as ITP is concerned. Even under an unchanged external environment the successful application of policy will affect the business

The Policy Environment: Constraint or Focus?

Traditionally SI theorists like Edquist and Lundvall in their writings would consider emergence of a ‘mismatch’ between actual and desired institutions as the background to policy actions. This reflects their focus on institutions as the central component of SI transformation, at least implicitly (rather than the Business Sector and its transformation as is the case here). While this approach embodies an important component of a country’s Policy Environment, it is only one among many. Power relations within a country’s elite, bureaucratic routines, ideology, dependence on international institutions; the vision, policy perspective and policy capabilities of policy makers are a few other factors comprising the country's Policy Environment. Finally, lack of information & knowledge may influence choices; and there may also be preferences for certain programs(or program designs) or for some strategic priorities over others.

The Policy Environment plays two main roles: a) it mediates between ITP *Knowledge*(e.g. ITP Normative Principles) on the one hand and the specific ITP applied in a particular country; and b) it influences the set of actions (and their impact)taken to induce the transition towards an integrated policy process. In both roles it *constrains & focuses* policy making activity. In the extreme case, the Policy Environment may be such that the attempt to generate a better PPP will in part fail, with the effect that a clear PPP Bias will characterise the new PPP arrived at. This would seem to be a common situation, as illustrated by some of the cases of the last sub-section. Thus some countries entering an ‘innovation phase’ with a strong need for a PPP1 (focus on Direct Support of R&D/Innovation in Business Firms) would choose instead PPP 2 (emphasis on the SS). The ensuing **bias** (see examples in 3.3 above) may truncate the process of diffusion and routinization of R&D, and cause slower growth.

Alternatively the Policy Environment of a country could provide **a focus** for policymaking which will help and reinforce (e.g. through interactive learning) rather than constrain, the above-mentioned process. ITP General Principles by themselves are too broad to provide a focus. This parallels the positive role that *focusing devices* play in guiding the activity of innovative engineers(Rosenberg 1976). Thus the prior existence of a NITPC in the country -one could consider this a major aspect of the

sector which calls for a measure of policy restructuring. Such co-evolution between policy and the business sector has led to the notion of the Technology Policy Cycle(see 2.3.9 at p.22 above).

Policy Environment itself-⁴¹ may help focus attention on the need to set new priorities and to shift from a truncated to an integrated policy process--rather than fiddling first with existing programs before realising--through failure and broader search for information about the environment facing the country- the futility of this procedure . Also a clear view of the changed environment facing the country and of the adaptations required, may overcome the inherent conservatism of existing lobbies and propel real change. Without this focus, the required changes would be much more difficult if not impossible to implement.

Taking account of a country's Policy Environment is a complex process which can be facilitated by identifying a small number of relevant *Policy Environment Types*; and by developing the knowledge base with respect to Theory and Data for each one of them. For example in one such type, the effective constraint might be the 'information & learning' base for inducing the required changes while in another it would be the power of existing lobbies which would block any change in the country's PPP. Such a set of 'typical' Policy Environment Types will become an additional area of application-friendly 'knowledge' or 'theory' within the SI perspective to Innovation & Technology Policy.

SUMMARY AND CONCLUSIONS

The major objective of this paper was to systematically analyse the Systems of Innovation perspective to Innovation and Technology Policy (ITP) with a view of applying it to concrete policy settings. Systems of Innovation research has focused until now on the Positive rather than on the Normative Side. This coincides with the view prevailing in quarters within Academia that policy is simply application (an "artifact" in the language of Layton and Vincenti). It is also one of the reasons why—beyond the incorporation of 'systems of innovation', 'learning' and 'interactions/links' into Policy Makers language—not much progress seems to have been made.

The approach followed is to see the SI perspective to ITP first and foremost as an area of **theoretical knowledge** whose *general principles* and *other knowledge components* may contribute to the design and implementation of policies in different national settings. Beyond the general principles of the *positive* side of the SI

⁴¹ As in Finland during the second half of the 90s; Hong Kong in 1997; and Israel during the first half of the year 2000.

perspective (most of which have appeared in the literature and are only briefly summarised here), I analysed ten ITP “Salient *Normative* Policy Principles or Themes” including: Adaptive Policy Maker, An Explicit Strategic Dimension; Policy as Judgement, Learning and SI transformation a major objective of ITP; the importance of new system components, explicit consideration of Demand; the importance of both institutions and of incentives; a focus on both R&D and on non-R&D factors; etc. These principles are amply illustrated with examples, mostly from Israel (the country whose ITP I know best). I have also proposed a typology of programs which follows a SI perspective, and suggested two "Reference" Program Portfolio Profiles (PPP) which would help focus the analysis of PPP Biases in industrialising countries at the "imitation" (Korea, Indonesia) and "innovation"(Korea, Israel, Argentina) phases. The analysis also considers other components of the SI perspective to ITP more directly related to Application in specific country settings. These include *The Policy Process* and *The Policy Environment*.

The central items of this paper seem to me to be a) presenting the Normative Principles of ITP as an integrated whole; b) elevating the Strategic Dimension of ITP (including its integration into a view of the 'Policy Process' which parallels that of the 'Innovation Process') to the status it deserves in the present world environment with continuous, and sometimes chaotic change; and c) Specifically dealing with knowledge items relevant for Application--Reference PPPs based on a SI-based program typology; the notion of PPP Bias which is a step forward towards determining a Strategy-Friendly PPP; and linking an analysis of the Policy Environment to a transition from a 'routine' policy process to an 'integrated' one. .

This paper should be regarded as only a rudimentary outline of what could become a well developed, application-friendly Systems of Innovation perspective to Innovation & Technology Policy. Major gaps are absence of a thorough discussion of institutions, both as policy items and as a central element of a country's policy portfolio. Much has yet to be done in this respect, including integrating our business sector & incentives' orientation into a wider SI perspective which integrates these with a more 'institutional' perspective.

Despite many doubts about the usefulness of the SI perspective (or the National SI perspective) I firmly think it is the only perspective which is broad enough and dynamic enough to accommodate, in today's Global Environment, a large

variety of situations. Therefore fleshing out this perspective to ITP remains a major challenge of the Evolutionary & SI Academic community.

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