



Workshop
“New economic ground for Innovation policy”

Bilbao (Spain), 14 September 2009

Agenda

- 9 h Welcome and opening speeches
Jos Leijten – (JIIP director – 6CP Steering Committee)
Joseba Jaureguizar (General Manager of Tecnalia)
Pedro Hernández (Basque Government, Vice-councillor of Innovation)
- 9:30 h John Barber. Setting the Scene
- 10:15 h Jan Fagerberg (University of Oslo). New foundations for Innovation policy:
research directions
Discussant: *Torsti Loikkanen (VTT)*
- 11:00 h Coffebreak
- 11:30 h Alasdair Reid (Technopolis): Lessons from INNO-policy Trendchart
Discussant: *Begoña Sánchez (Tecnalia)*
- 12:15 h Petri Peltonen (Ministry of Employment and the Economy, Finland). Lessons
from the 1990 recession in Finland.
Discussant: *Marcel Klein (Senter/Novem)*
- 13:00 h Lunch
- 14:30 h Marko Hekkert (University Utrecht): The challenge of sustainable innovation
policy.
Discussant: *Ken Guy (EC JRC / IPTS)*
- 15:15 h Henry Etzkowitz (Triple Helix Association, Stanford University): “Picking
winners” Revisited: Government’s role in Innovation during an economic
crisis.
Discussant: *Joschen Markard (Eawag)*
- 16:00 h Coffebreak
- 16:30 h Dirk Pilat. (OECD): The OECD Innovation Strategy. Towards an agenda for
policy action on Innovation
Discussant: *Steffen Kinkel (FhG ISI)*
- 17:15 h Lennart Elg (VINNOVA) and participants: Lessons learned
- 18:00 h Closing by Jos Leijten

**6CP Workshop: New Economic Ground for Innovation Policy
Bilbao 13-14 September 2009**

Setting the Scene – John Barber

Introduction

In this note I start by describing the traditional rationale for public policy towards innovation and technology development in terms of market failure within the standard neoclassical economic model. I suggest that this approach has become increasingly unsatisfactory as research into innovation and analysis of the impact of innovation policy measures means that the list of identified market failures has become longer and longer so that the standard neoclassical model becomes modified to a degree which undermines its validity. I then examine arguments of Douglass C North in his Nobel Lauriat lecture that neoclassical economic theory is an inappropriate tool for analysing the processes of economic development and innovation.

2. Next I briefly describe the evolutionary model of economic development and the National Innovation Systems (NIS) as providing an alternative to neoclassical economic theory as the basis for innovation policy. I suggest an approach to innovation policy-making in which they provide the means of constructing an overall strategy while analysis of market failure plays an important role in the selection of detailed policy measures. Finally I consider the ‘marketing’ of innovation policy to the wider audience and how this might be helped by the criticisms of mainstream economics which have arisen due to the credit crunch.¹

The rationale for innovation policy

3. Public policies to promote innovation and technology development have been traditionally viewed as government interventions in activities which are primarily the responsibility of commercial firms operating in the market place. Such interventions are seen as requiring an overall rationale which can be seen as consisting of the following three elements:

- a) Identification of some aspect of national (or regional) innovation performance which is regarded as unsatisfactory or some future worthwhile objective or strategy whose achievement is threatened;
- b) Identification of a defect in the working of market forces, or in the functioning of the innovation system, that seems likely to prevent the weakness in performance from being corrected or worthwhile objective being realised at least within a reasonable timescale. It is this element which is usually referred to as the ‘rationale’
- c) Some form of public support or intervention which will eliminate or offset the defect at a cost which is (expected to be) less than the benefits thus realised.

All of these elements must be present if a particular innovation policy can be justified ex-ante and be successful ex-post in yielding value for money.

¹ A more learned discussion of many of these issues can be found in “Building effective ‘innovation systems’ versus dealing with ‘market failures’ as ways of thinking about technology policy” by Richard Nelson in “The New Economics of Technology Policy” ed. Dominique Foray, Edward Elgar, 2009. I only saw this rather late in the day but its general conclusions are consistent with mine. See also Ed Steinmueller’s chapter in this book.

4. Standard neoclassical economics² views the market as working more or less perfectly. Atomistic agents have perfect knowledge of the factors which affect the outcome of their decisions, have unlimited capacity to compute those outcomes and make fully rational decisions which the market coordinates to create a unique stable equilibrium in which no agent can be better off without another agent being worse off (Pareto optimality). A necessary condition is that agents enjoy all the benefits and bear all the costs of their decisions, in other words there are no externalities. Any mistakes including trading at non equilibrium prices can have no effect on final outcomes and thus on the ability to achieve market equilibrium.

5. Within this framework the rationale for public support for innovation is seen in terms of specific deviations from the conditions required for a unique Pareto optimal equilibrium. In particular the standard neoclassical literature identifies the following:

- Externalities where agents do not enjoy all of the benefits or incur all of the costs of their actions;
- Public goods where the consumption or use of a good or service by one agent does not exclude its use or consumption by another;
- Uncertainty, where agents cannot know in advance what the outcomes of their actions are likely to be, and risk where these outcomes are distributed according to some probability distribution;
- Economies of scale where the unit costs of an activity continue to fall as the scale of the activity increases. This can result in monopoly and barriers to potential new entrants to a sector or market.

The presence and significance of all of these market failures are contested within the community of neoclassical economists and only the first, externalities, is widely accepted as a rationale for supporting the innovation activities of firms.

6. The use of the standard neoclassical economic model as a basis for constructing the rationale for innovation policy has become increasingly unsatisfactory for several reasons. To begin with analysis by academic researchers and innovation policy makers of the problems encountered by innovating firms suggests the existence of failures additional to those listed in the previous paragraph. These include:

- **Incomplete information** where agents do not have all the knowledge of markets, technologies, and the state of the world generally that they need to design, evaluate, choose and implement the activities they may wish to carry out;
- The ability of agents to assess the information potentially at their disposal and use it to analyse and evaluate the options open to them is limited. Combined with limited information this means that agents' decisions are made within a framework of '**bounded rationality**';
- **The nature of information and knowledge.** The neoclassical model treats all information as codified, disembodied and easily understood and used by agents. In the

² I have not in this paper considered the development of New Growth Theory as a means of incorporating innovation into the neoclassical theory of economic growth. This partly because I think it provides a very constrained picture of innovation in the real world – as a former policy maker I do not regard knowledge production functions, patent races, etc as very much use in improving understanding – and partly for reasons of space. However NGT may provide a useful means of communicating with outside stakeholders particularly in Ministries of Finance and the numerical estimates it provides of the impact of innovation expenditures on economic growth can be invaluable in impressing sceptical politicians.

real world information only becomes useful when it has been absorbed into the knowledge base of individual agents a process which takes time and effort. To be useful one piece of information must be integrated with others within a customised decision framework in which its relevance and meaning can be evaluated. Much information is tacit and can only be acquired either as a result of learning by doing or in close proximity with those who already possess it. Asymmetry of information/knowledge between different agents may lead to non-optimal outcomes like the distortions exhibited by Akerlof's market for 'lemons'.

- **Information as a good is particularly prone to market failure.** It is a public good whose use by one agent does not preclude its use by another. It has economies of scale and scope in use and appreciates in value as it is used. It cannot be revealed prior to sale without giving it away. Different types of information are complementary and the value of one piece of information to an agent depends inter alia on what other information he or she possesses or has can access. Finally Information tends to be embedded in organisations (Duguid and Brown).
- Much information is therefore bartered across **networks** rather than bought and sold in markets. The existence of appropriate networks is therefore a key element in the successful operation of a modern capitalist economy. Agents may participate in both strong and weak networks. Strong networks typically provide the information which supports day to day commercial activity and routine innovation but may help to trap an agent in an existing view of the World. Weak networks play an important role in enabling agents to find new kinds of information and new contacts in other words in innovation (Granovetter).
- Neoclassical economics recognises the role which large fixed (sunk) costs can play in creating **barriers to market entry**. However knowledge/intangible assets can also provide very effective barriers to entry because of the difficulty which new entrants face in appropriating the knowledge in question due variously to the tacit nature of the knowledge involved, secrecy, effective IPR or the fact that the knowledge is embedded in organisational structures which are hard to reproduce. Tacit knowledge gained from learning by doing is particular hard for outsiders to appropriate.
- **Capital market failure.** Investors suffer from limited information and bounded rationality like other agents and the consequences of their actions will be similarly uncertain. Unfamiliar investments such as those involving new companies, novel technologies and innovative business models will appear too risky in relation to the anticipated returns as will some longer term investments. It may be particularly difficult to obtained external finance for investments in long-term knowledge creation such as research.
- **Path dependency** where the individual and collective actions of agents today determines the nature of the options open to them tomorrow. Path dependence is the combined result of (1) the ex-post irreversibility /non-malleability of investment in capital assets (2) externalities generated in the technological locality of the particular path the firm has chosen to follow, and (3) feedback benefits such as those produced by learning by doing (Paul David). In some instances firms may be locked-in to a particular combination of technology and business model so that they feel unable to adopt a new superior technology leaving this 'disruptive technology' to new competitors (Clayton Christensen "The Innovator's Dilemma");
- **Coordination failures.** Because of the complexity of the innovation process firms do not innovate by themselves. They interact with other organisations such as suppliers, customers, competitors, universities, research institutes, investment banks, government departments etc. to gain various kinds of technology, knowledge, information, market access and other resources. Such interactions take time, effort and resources to bring

about and in a fast moving world the pattern of cooperation between firms and between firms and other agents may far from being optimal not least because of lack of information about possible useful partners.

- In the real world **market participants are not necessarily the atomistic agents** found in economics textbooks. Many are organisations either organs of government or firms. Firms, particularly large firms, occur because the costs of certain transactions when carried out on an arms-length market basis are too high (Coase, Williamson) and it is more economical to carry them out within a social organisation which may be cooperative or hierarchical or more often some combination of the two. Firms are 'islands of central planning in a sea of markets'. Alternatively firms can be seen a collection of management competences which enable resources to be utilised in ways not possible for groups of atomistic agents (Edith Penrose). Many neoclassical analyses solve out the firm by assuming that its behaviour is solely determined by external market signals. However this is not usually a good representation of actual real world behaviour. Firms, particularly large firms, are organic and social not mechanical entities which can have considerably strategic discretion about how they respond to their environment.

7. The 'market failures' listed above overlap and interact with one another. The incidence and significance of market failure is much greater in a dynamic economy subject to rapid economic, social and technological change than in a static economy where things remain much the same. In the latter decision rules will evolve over time which, if not optimal, will be well adjusted to the conditions and opportunities that agents face. Agents will accumulate a stock of knowledge well suited to the decisions they need to take and potential risks can be evaluated on the basis of past experience. There will be time to develop institutional arrangements to deal with externalities and market access. The discussions of human decision taking which has accompanied the credit crunch suggest that when dealing with familiar problems people make decisions intuitively but when faced with the unfamiliar they need to compute. Change exposes problems of bounded rationality and inadequate information which lie dormant when the world is static.

The Neoclassical Economic Model is not adequate for the task of analysing innovation

8. Using the neoclassical model to account for innovation and technology failure is therefore only possible by allowing for an increasing list of market failures which go a long way to undermining the validity of the model itself.³ Douglass C North in his 1993 Nobel Prize Lecture states that "Neoclassical theory is simply an inappropriate tool to analyze and prescribe policies that will induce development. It is concerned with the operation of markets, not with how markets develop". Since innovation and technology development are key elements in economic development neoclassical models cannot account satisfactorily for them either. A theory which has one of its key assumptions that agents possess perfect knowledge is always going to find it difficult to explain how new knowledge is discovered and the processes by which agents learn.

9. Douglass North's main criticisms of the neoclassical model is that it is essentially static (does not include time) and that it fails to allow for the key role which institutions play in economic development and by extension in innovation. North points out that for neoclassical theory to explain economic development we would need a fully dynamic model of economic growth comparable in precision to general equilibrium theory which is most rigorous account we have

³ One is reminded of Ptolemy's system of astronomy which could only explain the actual motion of the planets by adding increasing layers of epicycles.

of how markets operate in a static context. Such a model is essential if a comprehensive and rigorous list of the market failures which affect innovation is to be drawn up⁴.

10. North defines institutions as “humanly devised constraints that structure human interaction. They are made up of formal constraints (rules, laws, constitutions), informal constraints (norms of behaviour, conventions, self-imposed codes of conduct), and their enforcement characteristics. Together they define the incentive structure of societies and specifically economies. Institutions and the technology employed in production and distribution determine the transaction and transformation costs that add up the costs of production.” Transaction costs are the costs of specifying what is being exchanged and implementing and enforcing the consequent agreements. When it is costly to transact, institutions matter.⁵ The neoclassical result of efficient markets requires that transactions costs be zero. The appropriate development and evolution of institutions is a key element in economic growth.

11. In the real World markets can only operate in a framework made up of institutions which may require a government, city state, religious body, guild etc to enforce them and resolve disputes. There needs to be a sufficient number of well informed buyers and sellers undertaking a sufficient volume of arms-length and open transactions so that prices for an given product are well determined and known to all potentially interested parties. The costs of transactions must not be so high as to offset the gains from engaging in trade.

An alternative to the Neoclassical Model

12. If neoclassical theory cannot account for economic development and innovation we must find alternative approaches which can do better. Evolutionary economics casts doubt on whether equilibrium exists at all. Every innovation creates scope for further innovation and the further accumulation of knowledge. The pace of the accumulation of knowledge varies across the economy leading to a restless economy with no fixed resting point (Stan Metcalfe). At the same time market forces impose order and select those innovations appearing to offer the best returns. The process of knowledge accumulation, changes in tastes and the operation of entrepreneurs and larger firms continue to generate new technological and business options. The development and evolution of institutions plays a key role in the evolutionary approach.

13. Capitalist economies are dynamic and restless and unless an individual market adjusts very quickly, as is the case with many financial markets, departures from Pareto optimality will be the norm. In many cases it may be more important for economic welfare that a market fosters innovation (including the introduction of novel goods and services), growth in productivity and output rather than achieve static efficiency at any one point in time. The absence of markets in new and potential goods and services may be just as, or even more, important than flaws in the functioning of markets in existing products.

14. A complementary approach to evolutionary economics is the use of the innovation systems framework. The concept of an innovation system provides a framework for describing and explaining innovation performance, how innovation takes place and how technologies are developed and diffused. According to Professor Chris Freeman (SPRU), one of the original inventors of the concept, the national innovation system (NIS) is the ‘network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and

⁴ In the January 1991 issue of the Economic Journal Frank Hahn argues that we are unlikely ever to see a fully specified dynamic economic growth model.

⁵ North attributes the discovery of the connection between institutions and transaction costs to Ronald Coase.

diffuse new technologies' *in the country concerned*. Institutions is a complex concept which includes both

- organisations which are active in the innovation process;
- laws, standards, practices, habits, beliefs etc which shape innovation behaviour.

Since successful technological innovation is conditioned by and changes in organisation and in business practices, models and strategies the NIS must analyse these as well.

15. The set of 'institutions' which affect a particular innovation or technology or the innovation efforts of any one firm may be clustered locally, by sector, regionally, nationally or internationally. The system of institutions which support one particular innovation may have little overlap with the system which supports another. The system of institutions which supports the total innovation efforts of a country will include important overseas influences. This will be particularly true of small countries but with the globalisation of trade, finance, investment and now science and technology it is becoming increasingly true of all. However countries are still sufficiently distinct in terms of their set of innovation related institutions to make it meaningful and useful to talk on national systems of innovation providing always that due attention is paid to international factors which affect a country's innovation efforts.

16. The concept of the NIS does not imply that the innovation system was consciously designed. Rather national systems evolve and are the product of national history, culture, norms laws and values, resource endowments, pattern of production etc. The process by which they evolve depends heavily on interdependencies and interactions between institutions and is path-dependent in the sense that developments create new options while precluding options which might have existed in an earlier period. Small events can be reinforced by positive feedback to become crucially important. For these reasons national innovation systems vary significantly despite the fact that global economic, scientific and technological factors exert constant pressure towards uniformity.

17. The innovation systems approach has the advantage that it demonstrates the wide range of factors which affect innovation performance. These include not just the activities of firms and the operation of markets but also the system of training and education, the science and public research system, public procurement, taxation, networks, institutions and infrastructure, the business environment generally and functioning of capital markets. In many of these areas public authorities play the main role in making sure that policy in these areas is innovation friendly. In others such as vocational training they play a significant but minority role; in these areas public-private partnerships will often have an important role to play. Only in some, for example funding of civil business enterprise R&D, do they intervene at the margin in a manner envisaged by a policy rationale wholly dependent on neoclassical economic theory. In the other two areas it is probably better to decide the respective roles of the public and private sectors in terms of who is (a) best placed to access the necessary knowledge, expertise and capabilities required and (b) has a mission best able to incorporate the objectives that need to be pursued. Note that because the processes of innovation and technology development change over time the boundaries between the private and public sectors may need to shift also.

18. Mainstream economists tend to divide the economy into clearly distinct public and private sectors. In practice the two tend to merge into one another and it is possible to think of an intermediate sector inhabited by organisations which are neither fully public nor fully private. These organisations might include private charities which fund research, non-profit research associations, public sector research institutes whose objectives are mainly to help commercial

firms, standards bodies, commercial activities of universities etc. Recently there has been a tendency to try and simplify the world by pushing many of these organisations wholly into the private sector. This is frequently a mistake as the mixed nature of their missions tends to reflect the real needs of an effective innovation system.

19. Since we do not have a single all embracing model which can help us determine the strategy and tactics of innovation policy we must be prepared to use a combination of models. This makes many mainstream economists unhappy, 'how do you choose which theory to use they ask?' The answer must be the theory which best encapsulates the key aspects of the phenomena or issue under discussion. For example if we are discussing expenditure on the long-term development of novel technologies then an evolutionary/NIS approach is probably best. If, however, the issue is expenditure on the development needed to bring an existing prototype to market then a framework based on neoclassical market failure may be more appropriate. It is interesting to note that the failure of the standard model of financial markets to predict and explain the credit crunch has led to calls by some pundits for the use of a combination of models to monitor and analyse the development of the world financial system. If such a practice becomes common then it might make the economic mainstream more comfortable with the use of several different models to determine innovation policy.

20. Innovation policy needs to have top-down and bottom-up components. A top down approach should start from an analysis of strengths and weaknesses in a countries innovation performance. This is best done using a national innovation system approach incorporating relevant international comparisons. This should be combined with an assessment of expected world-wide developments in science, technology, innovation and the economy and society generally to try and identify the opportunities and threats which the country may face in the future. From this an overall strategy can be developed which gives a broad picture of how the country should react and the broad objectives which innovation policy should pursue. This should indicate the kinds of detailed policies and programmes which are appropriate to the countries situation. However all proposals should be subject to a detailed ex-ante appraisal of their rationale, objectives, design and likely outcome taking. This bottom-up element is important because there have been many examples of proposals for new schemes designed to promote innovation and technology development which seem to be a good strategic fit but failed because of defects in their detailed design and implementation. UK experience indicates that analysis of market failure within standard neoclassical economic framework can play a very useful role in helping to assess the rationale, objectives and outcomes of proposals for new programmes together with the behaviour they are designed to influence. Recognised market failure can often help explain such behaviour but sometimes the behaviour requires an explanation which is not on the existing list. In this way policymaking can help improve codified knowledge of how markets etc. actually work.⁶

Explaining and Marketing Innovation Policy

21. I have tried to explain how an economic rationale can be constructed for public policy towards innovation and technology development. It is not comprehensive.⁷ However while it is vital to have a sound analytical framework for designing and assessing innovation policy there is

⁶ For a more a more detailed account of the construction of innovation policy see "Innovation Policy and Performance – A Cross-country Comparison", OECD, 2005

⁷ The ASIF report "Assessing the Socio-Economic Impact of the Framework Programme, University of Manchester, 2002" devotes 122 pages to this topic.

also the problem of 'selling' innovation policy to various stakeholders. These include politicians, taxpayers, business, other government departments, etc. whose policies may impact on business and most of all Ministries of Finance which administer national budgets. The latter usually think they understand economics by which they mean standard textbook neoclassical economics though many of their officials are not economics graduates. The formal training of these officials is typically confined to basic macro and micro economics as taught to first year or second year economics undergraduate. They have little understanding of the grounded research and appreciative theorising by which researchers into science, technology, innovation and business generally try to explain how the world actually works. Being busy their limited knowledge of economics tends to become a matter of belief rather than scientific understanding. They are therefore likely to be very suspicious of such a long list of market failures as in set out in paragraph 6 above. They are likely to be even more suspicious of approaches such as evolutionary economics of which they know hardly anything at all.

22. There has been much talk since the credit crunch of the need for decision makers to rely less on the standard neoclassical model of how the economy works and adopt alternative approaches which give a more accurate picture of actual economic behaviour. At the same time it is suggested that economist researchers need to rely much less of formal mathematical models and to make use of less precise but more realistic approaches such as case studies. This may well happen but it is likely to be a slow process. People are reluctant to change their core beliefs even in the face of contrary evidence (as the history of science shows) and there are huge vested interests amongst the economics profession in the neoclassical approach. An important role for 'market failure' in explaining innovation policy will remain for some time to come.

23. The scope for grounded research and appreciative theorising of how the economy actually works should increase. The development and adoption of new models of financial markets which incorporate 'market failure' will help the mainstream economic community have a better acceptance of innovation policies based on analogous constructs. Researchers into science, technology, and innovation can help this process by showing more clearly how their approaches relate to new mainstream approach. In their introductory chapter to 'New Frontiers in the Economics of Innovation and New Technology – Essays in Honour of Paul A. David' Cristiano Antonelli, Dominique Foray, Bronwyn Hall and Ed Steinmueller compare the journey of Jason and the Argonauts to secure the Golden Fleece to a journey from the capital city of neo-classical economics to the barbarian hinterland where true knowledge of innovation can be found. Can the heroes return to Athens with the Golden Fleece and will its significance be understood? Will Athens be able to understand that its past certainties were limited and fragile and based on static and incoherent assumptions?

7th September 2009

*6CP workshop: New economic ground for innovation policy
Bilbao, 13-14 September 2009*

Invited position paper for session:

New foundations for innovation policy: research directions

by

Jan Fagerberg (University of Oslo)

Email: jan.fagerberg@tik.uio.no

Introduction

In recent years there has been increasing attention paid to innovation and the term “innovation policy” has become fashionable. Although the term is quite new many of the elements of innovation policy are not. In fact many of the innovation policy “tools” have existed for a long time but under other names such as industrial policy, technology policy, science policy etc (Lundvall and Borras 2004). This points to the possibility that there may be a lot window-dressing going on in this area, e.g. that existing policy schemes, introduced – perhaps – for reasons that have little to do with innovation, are continued under a new and (currently) more fashionable umbrella. At least this is what happened in my own country, Norway, in 2004 when several different public organisations, dealing with everything from export promotion to regional development, were merged as “Innovation Norway”. Despite its name most of its resources continue to go activities that has little to do with innovation in any meaningful sense of the word (Fagerberg 2009). Hence, there appears to be good reasons for critically examining the innovation policy mix (in any country not just Norway!).

The fact that innovation policy to a large extent is a continuation of policy schemes previously carried out under other umbrellas (and justifications) also implies that the policy mix may contain elements that are contradictory and that the policy as a whole may be inconsistent (and/or ineffective). If so this is not necessarily due to any bad will by policymakers, it may equally well have to do with the fact that there are many stakeholders in the system that attach specific value to particular policy schemes and are able influence the policy mix. This holds at least in the Norwegian case, otherwise it would have been difficult to explain why most of the so-called innovation support has gone to a few resource-based industries and rural areas with a relatively small share of total employment. However, it cannot be excluded that this problem is made worse by the lack of more transparent theoretical basis on the basis of which policy can be assessed. It is high time, therefore, to rethink the theoretical basis for innovation policy. The purpose of this paper - drawing mainly on Schumpeterian and evolutionary thinking – is to contribute to such a discussion.

Why a sound science policy is not necessarily appropriate for innovation

In his classic treatises on the subject Schumpeter (1934, 1943) defined innovation as “a new combination” of existing knowledge and resources and argued that innovation thus defined was the source of economic and social change. Without such innovation, resulting from the activities of entrepreneurial individuals and firms, society would in his view be stagnant.

This view differs from the long dominant classical and neo-classical view, in which economic change (or growth) is seen as the outcome of accumulation of (scarce) resources. But with the advent of formal neoclassical growth theory (Solow 1956) it became clear that under the usual neoclassical assumptions factor accumulation is not consistent with long run growth in productivity. To allow for such growth Solow had to add an exogenous term which he and others saw as the result of (exogenous) advances in science. In this approach, science was seen as a resource of a particular kind, a so-called “public good”, which the market system was not well equipped to produce. Hence, to avoid growth to be constrained by such “market failure”, e.g., a deficient science-base, science needed to be provided for free by the state or heavily subsidized. This became the main theoretical basis for science, technology and – later - innovation policies. Despite later criticisms it continues to be an influential view, in my own

country for example, university deans use exactly these arguments every time there is a public discussion of allocation of resources to R&D.

There are several problems with this approach, however. First it is probably not a very good theory about how science and society interact. But we shall leave this for the time being. The main problem in the present context is that it has led policy makers to think of science and innovation as similar activities. But this is not the case. Science is about expanding knowledge, not necessarily with a practical purpose in mind. Innovation is about combining different types of knowledge (not necessarily novel), skills and resources to solve practical problems and try the solutions thus obtained out in practice (usually with a view to commercial application). Science is mainly practiced in universities or other publicly supported research institutions whilst innovation is largely performed by private firms. Hence, these two activities, although related to some extent, are associated with different goals, forms of organization and incentive structures. This suggests that what is sound policy for science is not necessarily appropriate for innovation.

What do we know about innovation (that may be useful for policy)?

“Stylized facts”

In this section I summarize some of the main lessons from the TEARI project which led to the publication of the Oxford Handbook of Innovation in 2004 (see also Fagerberg 2006).

First, there is a great deal of uncertainty involved in everything that has to do with innovation. In general it is impossible to pick successful innovations *ex ante*. Even for minor, routine-type innovations unforeseen obstacles may emerge that put the whole project in jeopardy. Hence, innovation defies planning. However, although it is difficult to foresee (and influence) the outcomes of specific innovation processes with any degree of accuracy, what (arguably) can be influenced is the tendency of society as a whole to innovate and its receptivity for new innovations.

Second, a key lesson from modern innovation research is that innovation is a broad phenomenon, e.g., there are several different types of innovations and all of these matter. Not only technological innovations of the product and process type, which are what people often use to focus on, but also organizational innovations are important. In fact, many of the most important innovations throughout history have been of the organizational kind such as, for instance, the new distribution system that accompanied the development of mass production in the US a century ago, or how Toyota and other Japanese companies reorganized the entire value chain in the car industry in the period following the end of the Second World War (Fagerberg and Godinho 2004, Lam 2004).

Third, innovation is pervasive. It is not limited to certain so-called high-tech industries, but flourishes in other industries as well, not to speak of services (von Tunzelmann and Acha 2004, Miles 2004), although the factors that matter for innovation (and consequently the available policy options) may vary somewhat from one sector to another (Malerba 2004). Although some innovations may be spectacular technological breakthroughs, the bulk of innovation in modern societies consists of relatively small improvements. It is probably a safe bet that the cumulative impact of these is as great (or greater) than that of the more “radical” or “revolutionary” ones. Moreover, different types of innovations are related. Technological breakthroughs typically open up opportunities for a whole range of new innovations (without which such breakthroughs may in fact be of little economic significance).

Fourth, innovation is a lengthy process that is intertwined with diffusion and fundamentally shaped by the learning undertaken through this process. Most of what we today consider as innovations, such as, for instance, the car or computer, is in fact the result of long historical processes of gradual improvement, and the incorporation of a long series of innovations.

What much of this boils down to is that some of the popular folklore surrounding the innovation phenomenon, focusing for instance on the construction of technologically very demanding devices, based on scientific breakthroughs, occurring in big laboratories with the help of very advanced and expensive equipment etc., may be a bit one-sided. Albeit some innovations are of this sort, many are not, including a lot of those that matter economically. As mentioned previously we now have relatively extensive evidence from several countries, based on surveys of innovation activities of firms, that consistently shows that what matters most for successful innovation is not so much the link with basic science, big public laboratories or universities, or IPRs for that sake, but close interaction with users (demand), suppliers and competitors (Granstrand 2004, Smith 2004).

(Some) implications for policy

These lessons may raise important questions for policy. Arguably, in many cases the policy discourse tends to focus too much on the resources available for innovation, e.g., R&D, rather than innovation as such, which – if anything - should be the prime target for policy. For instance, a well-known concern among policy makers has been that of too little investments in R&D compared to other countries. But it is important to keep in mind that differences in aggregate R&D intensities across developed economies are mostly due to differences in private, not public investments in R&D (which tend to be more equal across the developed world).

Moreover, there may be good reasons for reported R&D intensities to differ across countries on approximately the same level of development. To the extent that the innovation dynamics, including the role of R&D, differ across sectors, as recent innovation theorizing indeed suggests (see f.i. Malerba 2004), and countries' specialization patterns differ as well, the innovation systems of different countries may develop quite differently in this regard. Arguably, the relationship between sectoral and national innovation systems is likely to be a coevolutionary one, in which sectoral characteristics (and the needs of firms in these sectors) influence the development of the knowledge infrastructure, institutions and policies at the national level, while these factors influence the subsequent evolution of the national economy (Fagerberg, Mowery and Verspagen 2009). It follows that a historical perspective is essential in understanding the development of the innovation system and the innovation policy stance in any country. Simplistic, ahistorical “benchmarking” may easily do more harm than good.

Private investments in R&D depend on a number of factors, such as for instance the strategic orientation of management, the costs, the perceived risk, the demand for new, innovative products or services and the extent to which R&D is deemed necessary to be able catering for this demand. If demand is failing or risk considered too high (which may in some cases amount to the same thing), innovation projects will be abandoned (or not started), and the same applies to the associated R&D investments. Hence, it might be more relevant to ask what policy makers can do to influence the factors that we do know have a large impact on

innovation (and hence business sector R&D), rather than focusing exclusively on the resources available for innovation, which may in the end not be the constraining factor.

An important lesson from the literature is that innovation and diffusion must be approached as a whole (Kline and Rosenberg 1986). Without diffusion innovation is largely without economic effects. The diffusion process also gives rise to many new innovations. It follows that to boost diffusion of major innovations throughout the economy may in fact be a good innovation policy. It is important, therefore, to identify factors that hamper diffusion, and use policy pro-actively to remove such obstacles.

Furthermore, innovation is a pervasive and systemic phenomenon, that occurs as much in interfaces between firms and their environments, as in, say, R&D departments or institutions. In fact, a lot activities and policies that are not primarily directed towards innovation and R&D, may have a very important role to play for innovation, and this role probably far outweighs the effect of more consciously defined RTD support policies. Hence an innovation policy that wishes to have a major effect must venture into other policy areas and ask questions of what the innovation-diffusion impact of these policies may be.

One of the characteristics of Western Europe is a large public sector. It follows that it will be difficult for these innovation systems to be effective unless the public sector takes active part in innovation- diffusion. The public sector plays an important role in innovation-diffusion, both as a user of technology, and as a provider of skills, infrastructure and services. Moreover it is something that that belongs to the realms of policy, for which policymakers have responsibility, and can do something about. Diffusion orientated policy centred on social needs (Fagerberg 1999) appears to be a key mechanism because they may allow large parts of the public sectors to act as laboratories for experiments of diffusion and using new technology and generating new ideas and demands.

Following this approach, a major challenge would be how to transform the big spenders among the public sectors, such as education, health, communication, energy provision (in some countries) etc., into powerhouses for innovation. What would be needed is a transition to an experimental economy; in which experiments with new solutions/technologies would be the normal state of affairs, not the exception. Such an economy would no doubt generate more innovation, and higher R&D expenditure in the private sector. This would, however, also necessitate a tolerance among policy-makers and the general public for the failures that inevitably would accompany any transition to a more experimental policy framework. This is an important challenge for policy.

Innovation occurs through new combinations of exiting knowledge, skills and resources. As evolutionary theory (Metcalfe 1998) suggests, the broader and more diverse the knowledge base, the larger the scope for innovation. An important point for policy may therefore be to contribute to the necessary variety in the knowledge base available for innovation. In all except possibly a few very large economies (of which there are none in Europe) the most important source of such variety in the knowledge base will have to be found abroad. The ability of the entrepreneurs of a country to tap into the global pool of knowledge and use it productively will in the majority of cases be vastly more important the conscious creation of new knowledge at home. "Knowledge mercantilism" is a guaranteed recipe for failure. From this perspective, EU research policies, supporting collaboration between researchers and firms at a European scale, may be an important tool for securing openness to ideas and different sources/types of knowledge. Arguably, the most important effect of these programs may not

be that they subsidize research but that they facilitate the sharing of ideas. It may well be in the self interest of Europe to open up such programs to wider international participation, and some steps in that direction have also been taken in recent years. However, the same logic applies at the national level, and policy makers may be well advised to take this account.

The success of the experimental economy also depends on the ability of policymakers to engage large parts of the population in the process. Arguably, an efficient knowledge economy is a system with a high degree of acceptance for diversity, not only with respect to knowledge strictly defined, but also with respect to the cultural, religious and ethnic characteristics of the carriers of that knowledge (Fagerberg and Srholec 2008,2009). Any citizen that is excluded from this process due to gender, sexual orientation, religion etc. represents the loss of a potential entrepreneur and a drag on the innovation dynamics of society.

References

- Fagerberg, J. 1999. The Need for Innovation-Based Growth in Europe, *Challenge*, 42: 63-79.
- Fagerberg, J. 2006. What do we know about innovation and socio-economic change? Lessons from TEARI project, in Earl, L. and Gault, F. (eds.) *National Innovation, Indicators and Policy*, Edward Elgar, Cheltenham, 2006, pp. 11-23.
- Fagerberg, J. 2009. Innovasjonspolitiske virkemidler, http://www.kunnskapsdugnad.no/portal/page/portal/kunnskapsdugnaden/rapporter/artikkel?p_document_id=776253
- Fagerberg, J. and M.M. Godinho 2004. Innovation and catching-up, ch. 19. in J. Fagerberg, D. C. Mowery and R.R. Nelson (eds.), *Oxford Handbook of Innovation*, Oxford University Press, Oxford
- Fagerberg, J., Mowery, D. and Verspagen, B. (eds.) 2009. *Innovation, Path Dependency and Policy: The Norwegian case*, Oxford University Press
- Fagerberg, J, D. Mowery and B. Verspagen 2009. The evolution of Norway's national innovation system, *Science and Public Policy*, July (forthcoming)
- Fagerberg, J. and Srholec, M. 2008. National Innovation systems, capabilities and economic development, *Research Policy*, 37: 1417-1435
- Fagerberg, J. and Srholec, M. 2009. Technology and development: Unpacking the relationship(s), in |Lundvall, BA; Joseph, KJ; Chaminade, C., Vang, J. (Eds) "*Handbook of Innovation Systems and Developing Countries*", Edward Elgar Publishing, 2009 (forthcoming).
- Granstrand, O. 2004. Innovation and intellectual property rights, ch. 10. in J. Fagerberg, D. C. Mowery and R.R. Nelson (eds.), *Oxford Handbook of Innovation*, Oxford University Press, Oxford
- Kline, S.J. and N. Rosenberg 1986. "An Overview of Innovation", in R. Landau and N. Rosenberg (eds) *The Positive Sum Strategy: Harnessing Technology for Economic Growth*, Washington D.C.: National Academy Press, pp. 275-304
- Lam. A. 2004. Organizational innovation, ch. 5 in J. Fagerberg, D. C. Mowery and R.R. Nelson (eds.), *Oxford Handbook of Innovation*, Oxford University Press, Oxford
- Lundvall B.A. and S. Borrás 2004. Science, technology and innovation policy, ch.22 in J. Fagerberg, D. C. Mowery and R.R. Nelson (eds.), *Oxford Handbook of Innovation*, Oxford University Press, Oxford

- Malerba, F. 2004. Sectoral systems: How and why innovation differs across sectors, ch, 14. in J. Fagerberg, D. C. Mowery and R.R. Nelson (eds.), Oxford Handbook of Innovation, Oxford University Press, Oxford
- Metcalf, J. S. 1998. Evolutionary Economics and Creative Destruction, London: Routledge
- Miles, I. 2004. Innovation in services, ch. 16. in J. Fagerberg, D. C. Mowery and R.R. Nelson (eds.), Oxford Handbook of Innovation, Oxford University Press, Oxford
- Schumpeter, J. 1934. The Theory of Economic Development, Cambridge, Mass: Harvard University Press
- Schumpeter, J. 1943. Capitalism, Socialism and Democracy, Allen & Unwin, London
- Smith, K. 2004. Measuring innovation, ch. 6 in J. Fagerberg, D. C. Mowery and R.R. Nelson (eds.), Oxford Handbook of Innovation, Oxford University Press, Oxford
- Solow, R. M., 1956. A Contribution to the Theory of Economic Growth. Quarterly Journal of Economics 70, 65-94.
- Von Tunzelmann, N. and V. Acha 2004. Innovation in 'low-tech' industries, ch. 15. in J. Fagerberg, D. C. Mowery and R.R. Nelson (eds.), Oxford Handbook of Innovation, Oxford University Press, Oxford

Systems failures and innovation policy: do national policies reflect differentiated challenges in the EU27 ?

Observations from a decade of the European TrendChart on Innovation

Position paper presented to the 6 Countries Programme workshop on ***New economic ground for innovation policy***, 14 September 2009, Bilbao, Spain

Alasdair Reid, Director, Technopolis Group

alasdair.reid@technopolis-group.com

1. The systems failure rationale for innovation policy

Over the last 10-15 years, European policy-makers have increasingly begun to use the language of ‘innovation systems’¹ and to refer, at least implicitly, to ‘system failures’ as a rationale for public sector intervention in innovation activities². The shift in thinking recognises that the concept of market failure is not a sufficient explanation of why innovation systems under-perform and why governments should intervene. **Market failure** occurs when market mechanisms are unable to secure long-term investments in innovation due to uncertainty, indivisibility and non-appropriability of innovation process (Arrow 1962). Typically, a market failure manifests itself in an insufficient allocation of funding for risky and innovative investments. In the field of innovation policy, the response to a perceived market failure is generally to provide ‘direct’ funding (grants, etc.) to enterprises in order to lessen the risk of longer-term investments; or providing support for venture capital funds.

Apart from the market perspective, analysis of innovation process has to take into account also key deficiencies of companies and failures in systems (Smith 2000, Arnold 2004). Arnold (2004) differentiates four **systemic failures**:

- **capability failures** - inadequacies in companies’ ability to act in their own best interests, for example through managerial deficits, lack of technological understanding, learning ability or ‘absorptive capacity’;
- **failure in institutions**³ – inadequacies in other relevant NIS actors such as universities, research institutes, patent offices and so on. Rigid disciplinary

¹ The national innovation systems approach stresses that the flows of technology and information among people, enterprises and institutions are key to the innovative process. Innovation and technology development are the result of a complex set of relationships among actors in the system, which includes enterprises, universities and government research institutes. For policy-makers, an understanding of the national innovation system can help identify leverage points for enhancing innovative performance and overall competitiveness (see: <http://www.oecd.org/dataoecd/35/56/2101733.pdf>).

² Smith K. (2000) Innovation as a Systemic Phenomenon: Rethinking the Role of Policy, Enterprise and Innovation Management Studies, volume 1 (1): 73-102
Arnold E. (2004) Evaluating research and innovation policy: a systems world needs systems evaluations, Research Evaluation, volume 13(1): 3-17

³ In the literature on national innovation system, the term institution is taken to mean rules and routines such as the legal system, informal rules and their enforcement characteristics. The approach adopted here is to adopt the more conventional practice of using the term institution as a synonym for organisation.

orientation in universities and consequent inability to adapt to changes in environment is an example of such a failure;

- **network failures** - problems in the interaction among actors in the innovation system such as inadequate amounts and quality of links, ‘transition failures’ and ‘lock-in’ failures (Smith 2000) as well as problems in industry structure such as too intense competition or monopoly;
- **framework failures** – gaps and shortcomings of regulatory frameworks, intellectual property rights, health and safety rules, etc. as well as other background conditions, such as the consumer demand, culture and social values (Smith 2000).

Tsipouri, Reid and Miedzinski (2009) argued that deficiencies in the ‘governance system’ (policy-making, evaluation and learning processes) need to be recognised as a fifth form of system failure, termed ‘**policy failures**’. Hence, the difference in the capacities and effectiveness of governance in a country can be expected to influence positively or negatively innovation system performance.

In the context of system failures, Metcalfe (2004) has argued eloquently that the role of primary role of the state in terms of innovation policy is to facilitate the emergence of well-functioning innovation systems. In a system failure perspective, the public sector role is not to promote ‘individual innovation events’, rather:

“...it is setting the framework conditions in which innovation systems can better self-organize across the range of activities in an economy. Moreover, whereas the market failure approach leads to instruments that allocate resources to firms in the form of R&D grants or tax incentives, the systems failure approach leads to instruments that enhance innovation opportunities and capabilities. Because systems are defined by components interacting within boundaries, it follows that a system failure policy seeks to address missing components, missing connections and misplaced boundaries”.

If it is hypothesised that system failures are a more robust rationale for innovation policy, then there is also need to take into account how the type and degree of development of different national (or regional or sectoral) systems may influence the degree of intensity of the different types of system failures. Since Rostow (1956), it is widely accepted that economies move through ‘stages of development’ and that the factors driving each stage (and hence the public policies brought to bear on the actors in the economy) differ. This approach is applied for instance in the Global Competitiveness Report (2009) based on Porter’s (1990) variant of the stages of growth model in modelling determinants of competitiveness. In the GCR framework countries are categorised into factor-driven economies, efficiency driven economies and innovation-driven economies. At each stage the basic requirements change, with the last depending on business sophistication and innovation.

Similarly, Aghion (2006) has argued that Europe’s lagging performance in growth and productivity is, indeed, partly a reflection of the need to invest more in innovation as the gains from capital accumulation and technological imitation were exhausted in the last quarter of last century. Indeed, he notes that the survival and growth of *all* industries (from textiles to pharmaceuticals) in a high-cost, high productivity economy depends on their ability to innovate. Following this line of reasoning, the Barcelona target (or at least the aim to increase R&D expenditure) is relevant since as EU countries move closer to the world technological frontier, they should invest more in R&D, and within the EU, the most advanced countries should invest proportionally

more as they benefit from a higher productivity of R&D⁴. However, Aghion goes on to argue that Government intervention to support R&D and innovation will be ineffective if the basic micro and macro-economic conditions for innovation-based growth are not in place, namely i) competition and market entry, ii) investment in higher education, iii) reform of credit and labour markets and iv) counter-cyclical fiscal policy⁵. Similarly, Metcalfe (2005) argues that the systems failures approach takes for granted the significance of an economic climate, with low real interest rates and stable macroeconomic and monetary conditions that encourages investment in all forms.

...the primary role of the state is to facilitate the emergence of innovation systems. In so doing it takes responsibility for the ecology of public organizations and institutions that facilitates business experimentation but recognizes that without the necessary interconnections the ecology is not a system. Since competition depends on innovation and innovation depends on the emergence of distributed innovation systems, it is clear that this provides an interesting alternative to the market failure perspective on innovation policy.

It seems fair to deduce as a hypothesis, therefore, that depending on their closeness to the technological frontier, their level of development and the type and extent of failures in their innovation systems, **different EU Member States need to adopt a differentiated “innovation policy mix” in order to boost their innovation performance**. Aghion’s argument about the closeness to the technological frontier implies that *“it is not enough to invest more in R&D here and there to get the economy to grow faster”*. Equally, considering the ‘pillars of competitiveness’ type logic or Aghion’s four ways of fostering innovation-based growth, the emphasis of a ‘broad-based’ innovation policy (the linkages the core instruments of ‘traditional’ innovation policy instruments and those of other policy domains) may need to vary.

As almost all EU27 Member States are already in an ‘innovation-driven’ phase (or in other words close to the technological frontier) there is a need to dig deeper to understand how differences in innovation systems, micro- and macro-economic conditions and the policy mix influence innovation performance. The European Innovation Scoreboard (EIS) provides the most robust and long-standing framework for such a categorisation of European countries. However, the EIS mainly captures the inputs and output to innovation systems and only touches upon the importance of the way in which the ‘components, connections and boundaries’ of NIS act as barriers or drivers to improved innovation performance (and ultimately growth). As Gault and Huttner (2008) have argued

⁴ Indeed the reflection can be extended further by considering the relative R&D productivity and specialisation of a limited number of EU27 regions that dominate in terms of R&D expenditure and outputs. See Peter V and R. Frietsch (2009), Exploring Regional Technology Specialisation: implications for policy. Regional Key Figures of the ERA series. DG Research, European Commission.

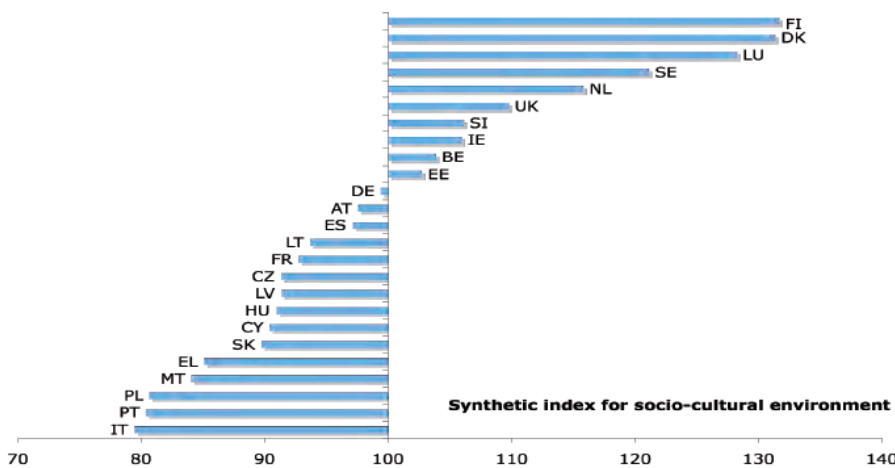
⁵ As Gault and Huttner (2008) argue: *It is difficult for public policy to influence such a complex system. A whole-government approach requires coherent and comprehensive analysis of the system dynamics, and robust statistical measures that describe the actors and processes at work. Without these, policies that make sense on their own may, in combination, produce suboptimal outcomes. Take R&D subsidies. A simple science policy might expect high subsidies to enhance the flow of knowledge. But that benefit might be eroded by relatively high corporate taxes, a fiscal policy necessarily influenced by the subsidies. Pull one thread in the system and distant actors could be affected.*

The dynamic and complex nature of innovation requires a systems approach to analyse both it and the policies that influence it. All the actors – governments, businesses, institutions of education, foreign institutions and more – need to be included in the analysis, as do their activities – R&D, innovation, technology diffusion, commercialization of knowledge. The links between these actors and activities and their outcomes must also be accounted for, including all the feedback and feed-forward loops that engender the messy, nonlinear nature of innovation.

In short, to design better innovation policies, there is a need to develop and monitor a broader set of indicators beyond the quantitative ones traditionally used not only to appraise performance but also as ‘targets’ for Governments to meet (in a somewhat tautological manner, most national governments observe that their national R&D/GDP rates are too low and hence set the objective to boost them, without necessarily undertaking a more extensive reflection on the factors behind this perceived ‘under-investment in R&D’). Hence, designing better innovation policy requires the development of indicators and metrics that improve the ability to understand the performance of institutions and linkages between the actors of innovation systems. As Freeman (2006) argued:

“The huge divergence in growth rates which is so obvious a feature of long-term growth over the past two centuries must be attributed in large measure to the presence or absence of social capability for institutional change, and especially for those types of institutional change which facilitate and stimulate a high rate of technical change. Nowhere has this been more apparent than in Eastern Europe“.

Figure 1: socio-cultural environment and European innovation systems



Source: Bruno et al (2008)

Interpreting one-off ‘social surveys’ such as the InnoBarometer to try and ascertain whether a national innovation system is more or less open to institutional change, technological adoption and organisation innovations is fraught with difficulties.

However, Bruno et al (2008) brought together evidence from a range of surveys and more standard statistical sources to investigate the ‘socio-cultural factors’⁶ influencing innovation in the EU25 (EU27 minus Bulgaria and Romania). The results are summarised in a synthetic indicator in Figure 1 and while the top and bottom performers are not markedly different from the EIS outcomes, some countries do perform considerably worse than their position in more classic scoreboard outcome, notably Germany, France and Italy. Further exploration of the ‘softer’ and systemic factors determining innovation performance would help to inform policy debates on how best to boost innovation performance and create an innovation ‘culture’ or ecosystem.

2. Innovation policy: shifting boundaries ?

Innovation policy is defined as “*a set of policy actions to raise the quantity and efficiency of innovation activities whereby innovation activities refer to the creation, adaptation and adoption of new or improved products, processes or services*” (Cowan & Van de Paal, 2000). In contrast, science (or, as it is commonly termed in the EU, research) policy is concerned with the production of knowledge: it is the art of justifying, managing or prioritising support of scientific research and development (R&D)⁷. To put the distinction in the simplest terms, science policy is concerned with the production of knowledge, while innovation policy aims to improve the overall innovative performance of the economy (Lundvall & Borrás 2005). A ‘grey area’ of over-lapping competence between both policies concerns linkage or bridging policy measures (e.g. competence centres, collaborative technology programmes, technology transfer and commercialisation structures in universities, etc.) and financial support for industrial R&D, both types of instruments seeking to foster the application of knowledge. In addition, it is clear that innovation policy does not intervene in a vacuum and a whole host of other policies (macro-economic, education, etc.) influence innovation performance⁸.

Innovation policy needs to focus on all types of innovation activities and processes in enterprises (at all stages in their development from a business idea to a mature firm seeking to renew its product range, etc.) and not only on R&D or technological innovation⁹. Although private companies are rarely involved in the basic production of knowledge, they do undertake/fund applied or experimental R&D in the course of product or service design.

⁶ Four ‘capitals’ (or dimensions) were used to identify the socio-cultural characteristics of NIS relevant to innovation: cultural capital & consumer behaviour (or demand for innovation); human capital; social capital, and organisational capital & entrepreneurship.

⁷ Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications (OECD Oslo Manual 2005).

⁸ The ‘policy-mix’ study funded by DG Research of the European Commission is a useful source of reference for further insights into the conceptual understanding of the interactions between research and innovation policies, and other sectoral policies. See Nauwelaers C. et al (2009).

⁹ Technological product and process (TPP) innovations comprise implemented technologically new products and processes and significant technological improvements in products and processes. TPP activities are all those scientific, technological, organisational, financial and commercial steps, including investment in new knowledge, which actually, or are intended to, lead to the implementation of technologically new or improved products or processes. (OECD Frascati Manual 2002)

The final beneficiary or target of innovation policy is thus enterprises¹⁰ (including early-stage entrepreneurs seeking to establish an enterprise)¹¹. However, from a systems perspective, innovation policy may choose to achieve its aim by supporting 'indirect beneficiaries', whether these be financial organisations (seed capital funds, etc), innovation and business support services, cluster management partnerships, knowledge transfer structures in universities, public research organisations, etc..

A second intrinsic characteristic of innovation policy, setting it apart from science policy, is that it aims explicitly to support non-technological innovation¹². Indeed, innovation policy focus on what Tidd et al (2005) called the 4Ps: product innovation, process innovation, position innovation, paradigm innovation¹³. Hence, policy measures need to encourage not only formal industrial R&D but also innovative organisational practices, design and creativity and the diffusion and application of ubiquitous technologies (information and communication technologies, biotechnology, nanotechnology)¹⁴.

Moreover, a quite extensive literature on sectoral innovation systems¹⁵ suggests that specific sectors of the economy face different challenges due to different market structures and industrial dynamics, that innovation is driven by different factors (sources of innovation, demand, etc.), that technological regimes (the knowledge and learning environment in which firms operate) and that innovation processes or modes are organised differently, etc.¹⁶. Indeed, the OECD (2005) argues that:

"Innovation processes differ greatly from sector to sector in terms of development, rate of technological change, linkages and access to knowledge, as well as in terms of organisational structures and institutional factors.

¹⁰ Science policy, in contrast, is implemented in three major venues: educational institutions, governments or publicly funded institutes, and not for profit or philanthropic organisations.

¹¹ The word enterprise is used to essentially refer to profit seeking private enterprises, however third-sector, not for profit companies, and increasingly public sector organisations, e.g. health sector, are also seeking to improve their 'innovation performance'. See also the MONIT definition of sectoral innovation or innovation in other policy domains later in this chapter.

¹² Non-technological innovation covers all innovation activities, which are excluded from technological innovation. The major types of non-technological innovation are organisational and managerial innovations: the implementation of advanced management techniques, e.g. TQM, TQS; the introduction of significantly changed organisational structures; and the implementation of new or substantially changed corporate strategic orientations.

¹³ The four types of innovation are defined as follows: product innovation: changes in the things (products/services) which an organisation offers; process innovation: changes in the ways in which they are created and delivered; position innovation: changes in the context in which the products/services are introduced; paradigm innovation: changes in the underlying mental models which frame what an organisation does.

¹⁴ For a review of the 'ubiquitous' impact of ICT on economic activity, see: OECD (2004) The Economic Impact of ICT: measurement, evidence and implications.

¹⁵ Malerba F. (2005) Sectoral Systems: how and why innovation differs across sectors. In Fagerberg J, Mowery D.C. and Nelson R. (Eds.) (2005). The Oxford Handbook of Innovation.

¹⁶ However, the current industrial classification system (the NACE codes) are increasingly inappropriate as a mechanism for describing a set of common business activities even in more 'traditional sectors' (e.g. is a company operating in the field of technical textiles, an apparel company, a fine chemical company, a supplier of industrial materials, a supplier to the automobile industry etc.). Hence, if differences exist in sectoral innovation systems they may be hard to capture due to the multi-sector activities of many innovative firms, notably larger ones. See the body of evidence on sectoral innovation systems developed under the EU funded Sectoral Innovation Watch project (2005-2008): www.europe-innova.org

Some sectors are characterised by rapid change and radical innovations, others by smaller, incremental changes. In high-technology sectors, R&D plays a central role in innovation activities, while other sectors rely to a greater degree on the adoption of knowledge and technology. Differences in innovation activity across sectors (e.g. whether mainly incremental or radical innovations) also place different demands on the organisational structure of firms, and institutional factors such as regulations and intellectual property rights can vary greatly in their role and importance. It is important to take these differences into account when designing policy.

Certainly, the sectoral composition of national economies appears to play a decisive role in terms of the trends and intensity of business investment in R&D (BERD)¹⁷. The role of the structure of the economy (structural effect or ‘between-industry’ effect) appears to be more important as an explanatory factor than sector-specific R&D intensities (intrinsic effect) in explaining differences between the EU27 and US rates of R&D investment (Duchêne 2008). This should give pause for thought to policy makers in EU countries trying to boost national BERD intensity, to be in line with the EU’s “Barcelona target” (3% GERD/GDP ratio, of which two-thirds from BERD) target, with national industrial structures skewed towards medium-to-low technology sectors.

Thirdly, a series of theoretical and empirical approaches have equally placed greater emphasis on the ‘demand side’ of the innovation process, underlining that the sources of inspiration for innovations are as often drawn from consumers, co-developed by users (Von Hippel 1988), influenced by standards-setting processes to target lead markets, boosted by public procurement (Edler 2005, Georghiou 2007). These strands of thinking have rapidly found their way into policy development processes notably through the impulsion given by the Aho report (2006). This report argued that the reason business is failing to invest enough in R&D and innovation in Europe is the lack of an innovation-friendly market in which to launch new products and services. To create such a market they recommended actions on: harmonised regulation; ambitious use of standards; driving demand through public procurement; a competitive intellectual property rights regime; fostering a culture which celebrates innovation.

The argument is hence that it is not enough for policy to focus on attempting to boost knowledge creation and transfer from academic or public sectors to enterprises or correcting the market failures that lead to enterprises under-investing in R&D. In this context, much of the recent literature on innovation policy underlines the need to shift to a horizontal (or cross-cutting) form of policy intervention, the so-called ‘third-generation’ innovation policy¹⁸. Innovation policy, hence, transcends traditional sectoral (or vertical) policies such as science, education and training, environmental, transport, health, etc.

Yet, it should not be forgotten that, however defined, innovation policy in the EU has only a short history: it has developed as a ‘political objective’ since the Green Paper on Innovation (European Commission, 1995) and the re-focusing of traditional ‘industrial

¹⁷ The EU27 industrial structure is relatively more concentrated in medium-high-tech, medium-low-tech and low-tech activities than in the US (more concentrated in high-tech sectors and notably the larger share of both the ICT manufacturing industries and the ‘Aircraft and spacecraft’ industries in the industrial fabric of the US).

¹⁸ The so-called “third generation innovation policy” stresses the need for innovation to become an integrated dimension of other traditional policies. See: Innovation tomorrow: Innovation policy and the regulatory framework: making innovation an integral part of the broader structural agenda; Louis Lengrand & Associés; PREST (University of Manchester) & ANRT; Innovation papers No 28, 2002, European Commission.

policies' towards support for innovation has occurred over the decade in line with changing trends in EU State Aid rules¹⁹. This notably implies that 'horizontal measures' (such as support to innovation and industrial R&D) are to be preferred to selective measures targeted at certain ailing sectors²⁰.

The OECD MONIT study²¹ provided what has remained to date the best exploration of types of innovation policy (see. From one perspective, innovation policy can be considered as an extension of industrial policy (defined as the sum of public measures aimed at the development of industrial structures in a specific sector). 'Traditional' industrial policy is generally viewed as being limited to maintaining a status quo of a given industry sector or trying to help establish (or maintain) national champions with financial incentives. However, a more modern vision of industrial policy developed by Rodrik (2004) argues that instead of viewing industrial policy as an outcome ('picking winners') supported through a range of instruments (subsidies, tax incentives, etc.), it is a process whereby the state and private sectors jointly arrive at a diagnosis about the sources of blockage in new economic activities and propose solutions to them²².

Figure 2: A taxonomy of innovation policy, the MONIT approach

Goals	Sectoral innovation policy	Multi-sectoral innovation policy
Innovation policy, i.e. aimed primarily at innovating industries and economic growth	<i>Innovation policy in a limited sense (basically technology and industrial policies)</i>	<i>Integrated science, technology and innovation (STI) policies</i>
Innovation policy in a wider sense, i.e. aimed at economic growth and quality of life	<i>Innovation policies in other sectoral domains, e.g. in health, in the environment, etc.</i>	<i>Horizontal/comprehensive /integrated or coherent/ systemic innovation policies</i>

Source: OECD (2005)

Third generation innovation policies (the bottom right quadrant of the MONIT taxonomy above) and 'new' industrial policies are clearly part of the same family and indeed this is very much the policy orientation of the European Commission's industrial policy. According to the Commission, "the main role of industrial policy is to provide the right framework conditions for enterprise development and innovation in order to make the EU an attractive place for industrial investment and

¹⁹ The European Council has explicitly invited Member States "to continue working towards a reduction in the general level of state aid, while making allowance for any market failures. This movement must be accompanied by a redeployment of aid in favour of support for certain horizontal objectives such as research and innovation and the optimisation of human capital. The reform of regional aid should also foster a high level of investment and ensure a reduction in disparities in accordance with the Lisbon objectives". European Council Conclusions of November 2004 and March 2005

²⁰ A measure is considered "selective", if the authorities administering the scheme enjoy a degree of discretionary power. The selectivity criterion is also satisfied if the scheme applies to only part of the territory of a Member State (this is the case for all regional and sectoral aid schemes)". Vademecum Community Rules on State Aid, 2007.

²¹ OECD (2005) Governance of Innovation Systems, Vol. 1: Synthesis Report

²² Rodrik D., (2004) "Industrial policy for the twenty-first century," mimeo, John F. Kennedy School of Government, Cambridge, MA: Harvard University.
<http://ksghome.harvard.edu/~drodrik/UNIDOSEp.pdf>

job creation"²³. This is very similar in its argumentation to the role of government in supporting innovation systems outlined above.

However, in many countries, innovation policy has only become an operational reality from 2000, or even amongst the NMS with the advent of the first round of Structural Fund support in 2004. Accordingly, discussions on priorities for innovation policy still take place amongst a relatively small community of 'experts' in liaison with a limited, if growing, number of practitioners (regional or national agencies, innovation and technology centre managers, innovation fund managers, cluster managers, etc.). This leads, as will be discussed below, to a disconnection between agenda/objective setting in National Reform Plans or Structural Fund programming documents (often drafted in specialised departments of Ministries of Finance, etc.) and an evidence based priority setting based on a real understanding of the specific bottlenecks in the national (and regional) innovation systems. Indeed, it could be argued that there is a risk of an "unhealthy Europeanisation" of policies taking place, where countries try to adjust policies to an "ideal" set of guidelines rather than develop policies tailored to their specific stage in the development to a knowledge based economy (e.g. technology absorption measures in traditional SMEs versus strengthening global innovation hot spots') and without regard to the existing industrial (including services) structure, existing technological specialisation patterns, foresight on opportunities for carving out future competitive advantage; or trends in human resource for innovation, etc.

Innovation is paradoxically both at the top of the policy agenda (taking a word count in official EU or national development plans for instance); and yet a misunderstood concept in terms of policy design and delivery, squeezed between a powerful 'research lobby' and more classic economic or industrial development policies. The 'place' for a distinct policy intervention called innovation policy in a broader "policy mix" is not always well articulated, objectives are loosely defined, targets imprecisely set, intervention logics weakly articulated, external factors impinging on the success of implementation of measures poorly understood, a limited evaluation culture and even rarer impact analysis.

In innovation policy circles, the concept of a 'third-generation innovation' policy is widely held as being a model to aspire to while in practice many Member States, nationally and/or regionally struggle to implement even 'sector' or technology-specific innovation policy measures. Capturing the systems²⁴ dimension to innovation policy design and implementation is currently beyond the capacity of the vast majority of member states, with for instance action to influence framework conditions (legislation) or correct institutional failures rarely included in a systematic way. Equally, the need to create synergies not only with 'research policy' but also education, transport, environment, energy, etc. policies to adopt a more ambitious agenda for innovation policy where innovation is truly everywhere and in particular where policy seeks to lead to longer-term structural 'system innovation' is not happening (with some exceptions) due to administrative hierarchies and "turf wars".

In this context, the next section of this paper examines the challenges faced in designing innovation policy in a multi-level governance context within a EU composed of diverse economies and innovation systems. It does so by building on the database of policy information accumulated over a ten-year period by the European TrendChart on Innovation initiative (funded by the Directorate-General for Enterprise Policy of

²³ Commission Communication "Implementing the Community Lisbon Programme: A Policy Framework to Strengthen EU Manufacturing - towards a more integrated approach for Industrial Policy" - COM(2005) 474 final of 5.10.2005.

²⁴ The expression National System of Innovation was first used by Chris Freeman in 1987 in his book on technology performance and economic performance in Japan. For a recent review see Edquist Ch. Systems of Innovation, in Fagerberg J, Mowery D.C. and Nelson R. (Eds.) (2005). The Oxford Handbook of Innovation.

the European Commission). The analysis presented here is based largely on the European Innovation Progress Report 2008²⁵ and on an on-going analysis of the TrendChart database enabling a characterisation of national policy mixes through a set of quantitative and qualitative indicators.

3. Does the innovation policy mix tackle system challenges ?

In Tsipouri et al (2009), the concept of system failures was applied as an analytical framework for analysing innovation policy in the EU27 Member States. The analysis was based in a first instance on the policy challenges identified by the 2008 national reports on innovation policy and performance prepared by the network of TrendChart correspondents. Needless to say, the six types of failures do not constitute a strict categorisation and some interpretation is required. Policy challenges as defined by each national report may encompass one or more types of failures. Equally, policy measures addressing specific challenges may address more than one failure. For example, a measure aiming at increasing innovation capacity of companies through technology transfer between companies and research institutes can be classified as addressing both capability and network failures.

Figure 3: Examples of challenges per type of failure in the EU27

	Innovation leaders	Innovation followers	Moderate innovators	Catching up
Market Failures	UK: “Boost relatively weak intensity of innovation activity in Enterprises”	IE: “Increase the level of innovation in the private sector”	CY: “Increase inputs and efficiency of business Innovation”	BG: “Increase R&D expenditure (private and public)”
Capability failures	FI: “Broaden the base of innovative growth-oriented enterprises”	FR: “Increase non-technological innovation (organisational, design) innovation in SMEs”	EE: “Building competences and developing innovation management skills”	PL: "Stimulate and deepen innovation internal capacities of Polish companies"
Institutional failures	DE: “Increasing supply of highly qualified labour”	BE: “Innovation skills mismatch”	IT: Innovation financing	RO: “Improve innovation and business support infrastructure (business incubators, technology transfer offices, S&T Parks, etc.)”

²⁵ See http://www.proinno-europe.eu/admin/uploaded_documents/EIRP2008_Final_merged.pdf

	Innovation leaders	Innovation followers	Moderate innovators	Catching up
Network failures	SE: "Centres of Excellence: creation of globally competitive research and innovation milieux."	LU: "Reinforce synergies, complementarities and collaborations between the public and private RD centres."	CZ: "Cooperation between public R&D and industry"	SK: "Development of knowledge intensive clusters across public knowledge poles"
Framework failures	SE: "Innovative public procurement – Revitalising old models to transform knowledge to commercial value"	FR: "Foster intellectual property use by SMEs"	ES: "Decreasing availability of human capital and skills"	MT: "Sustaining enhanced investments in business R&D and encouraging innovation of SMEs"
Policy failures	FI: "Transformation of firm strategies and new innovation models".	n.a.	EL: "Low effectiveness and limited impact of the innovation measures on economy and employment"	SK: Underdeveloped innovation governance

Source: TrendChart Country Reports 2008, analysis Technopolis Group

Based on the challenges identified in the 2008 EU27 TrendChart country reports, the figure below summarises the relative weighting of innovation policy challenges across the six types of failures. As can be seen from Figure 4, capability failures are the most prevalent type of failures ahead of institutional and market failures. The recognition that capability failures (limited management skills, weak know-how on technological or organisational innovation, etc.) inside companies are a considerable impediment to intensifying innovation is significant.

A general refrain for many years has been to point the finger at 'lack of financing' (captured normally under the market failure or framework failure categories) as a major barrier to more SMEs innovating. The focus of the challenges on capability failures suggests that more attention needs to be given in policy support to alleviating internal factors sapping innovativeness of European enterprises.

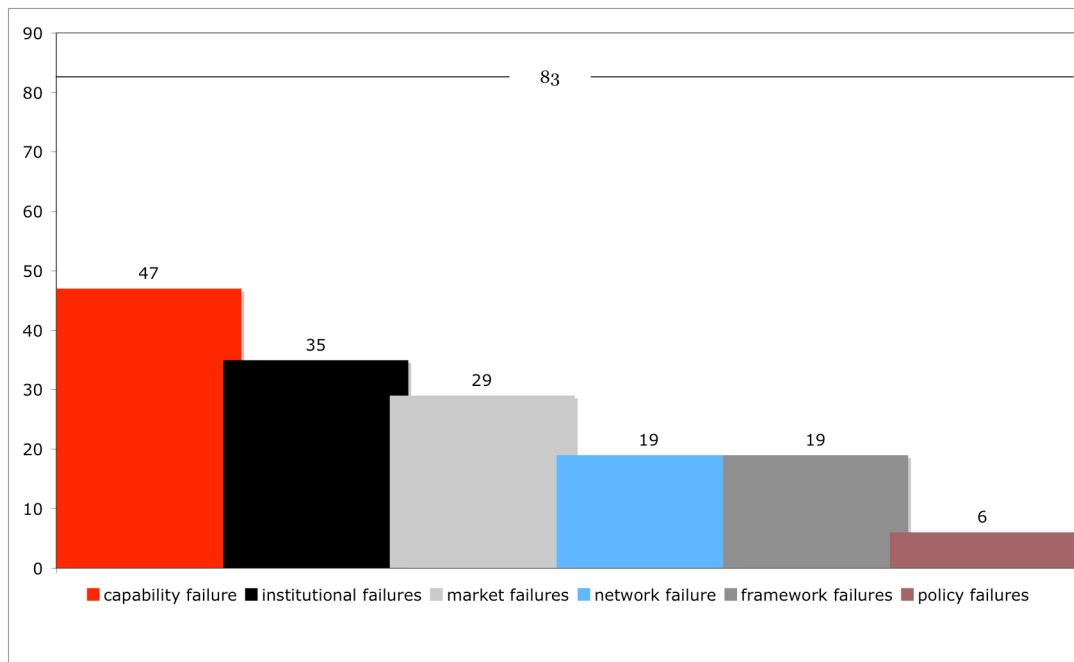
Figure 5 distinguishes the importance of the challenges identified by EIS 2008 country groups. While capability failures are perceived as an important challenge across all four groups, the shortcomings of framework conditions are considered more significant in the innovation leaders and followers.

This could be considered a paradoxical finding but it does not imply per se that framework conditions are weaker in these countries. Rather it is indicative that framework conditions are more often identified as a policy issue, possibly because the basic conditions (internal capabilities of enterprises, innovation infrastructure, access to finance or innovation support services, etc.) are better than in the lagging countries.

Perhaps surprisingly, network failures (industry-science co-operation, clustering, etc.), often highlighted in policy debates as a weakness of many national innovation systems in the EU, have been considered as a key challenge significantly less often than capability, institutional and market failures. Such network challenges were, however, relatively more present in the moderate innovators and the catching-up countries,

suggesting that innovation co-operation and knowledge transfer remain more problematic in these 'less-developed' innovation systems.

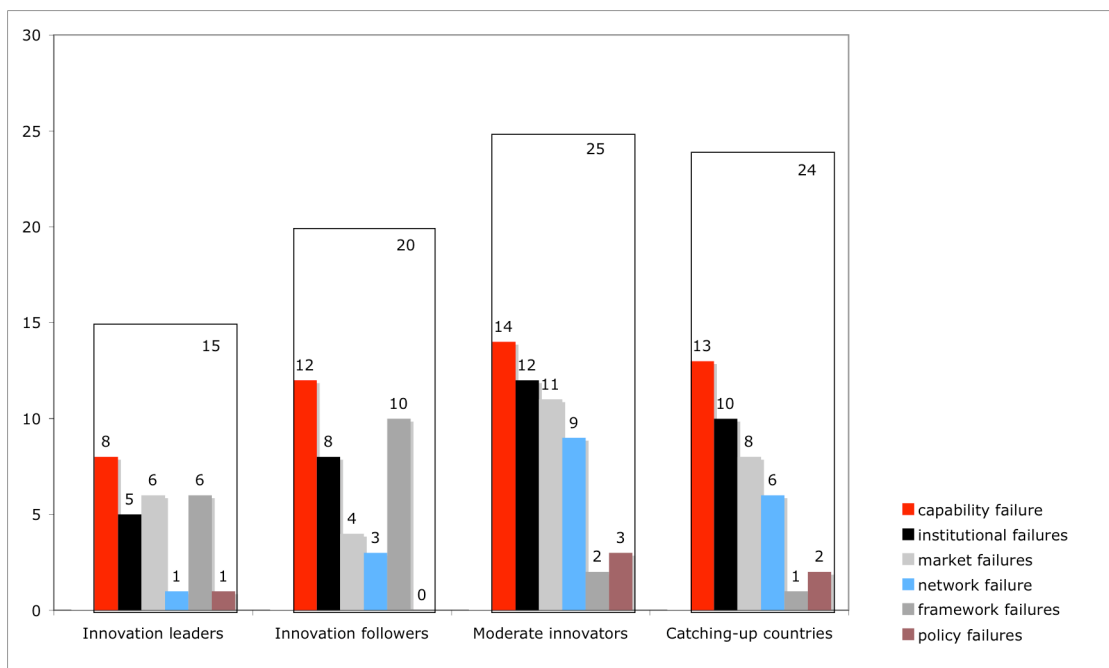
Figure 4: Failures targeted by EU27 innovation policy challenges



Source: TrendChart Country Reports 2008, calculations Technopolis Group

Nb: numbers over the vertical bars indicate the number of challenges addressing a given failure. A challenge can address more than one type of failure. 83 challenges were defined in the 2008 country reports.

Figure 5: Challenges by type of failure and EIS group



Source: TrendChart Country Reports 2008, calculations Technopolis Group

Note: The numbers over the vertical bars refer to the number of challenges addressing a given failure. The numbers in the right upper corner of the black frames are total numbers of challenges in EIS groups. One challenge can address more than one type of failure.

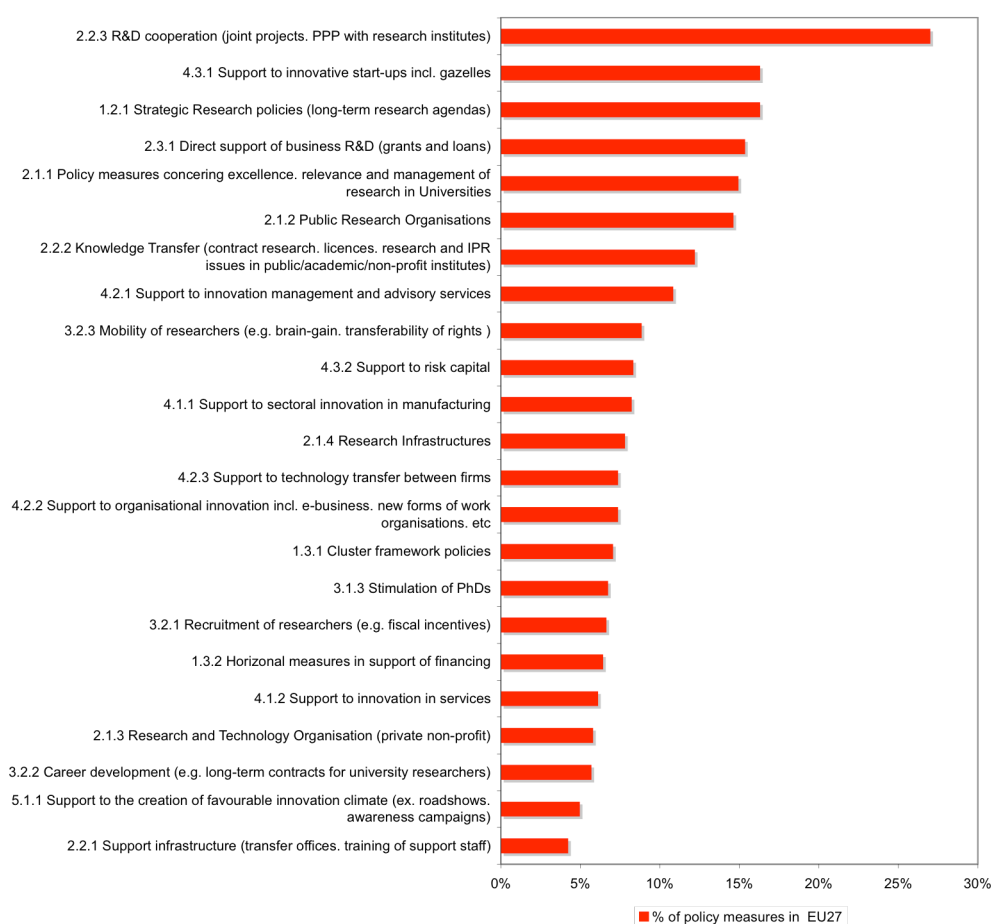
Experts in the “catching-up” countries were particularly concerned about network failures. The Hungarian report points to “Low occurrence of cooperation in innovation activities”; the Bulgarian correspondent called for action "To stimulate partnership and to increase cooperation between science institutions, enterprises and other institutions involved in the innovative process"; the Polish, Romanian, and Slovak reports highlighted the need to improve industry-science co-operation (as did the Czech report from the group of moderate innovators).

The concept of policy failures is less present in the analysis than might be expected, but this is largely due to the procedure for identifying challenges (based primarily on EIS indicators) rather than a sign that all is well in governance. Governance and policy management issues are dealt with in a separate chapter of the TrendChart reports and, indeed, when one delves into the country reports for the CEEC the weakness of governance systems (one element of the social capabilities discussed above) are a source of concern in all the national innovation systems.

4. What type of failures do innovation policy measures target?

According to EIPR 2008 (Tsipouri et al, 2008), the policy priorities²⁶ most often addressed by STI policies in the EU27 Member States during the period 2007-8 was by far ‘support for R&D cooperation including joint research projects run by public-private consortia of business and research’. Nearly one third of all support measures in force targeted R&D cooperation as one of their key priorities. Work in progress to update and deepen the analysis of the policy measure database (to be published in the forthcoming European Innovation Progress Report 2009) tends to confirm the importance of R&D co-operation. The policy priority most often addressed remains “*support for R&D cooperation*” (27% of measures²⁷).

Figure 6: frequency of measures targeting policy priorities in the EU27, 2009



Source: TrendChart-ERAWATCH database; analysis Technopolis Group (N=1094)

²⁶ In the TrendChart, STI policy measures are categorised according to a 3-digit structure and grouped into five main macro categories: governance & horizontal research and innovation policies; research and technologies; human resources (education and skills); promote and sustain the creation and growth of innovative enterprises; markets and innovation culture.

²⁷ Based on an extraction from the database in June 2009.

The next most often addressed priorities include ‘*implementing strategic research policies*’ (16% of support measures), *support to innovative start-ups* (16%), *direct support for business R&D* (15%), *measures targeting excellence and management of research in Universities* (15%) and *in research organisations* (15%).

Financing of innovation is often considered as weakness of national innovation system, however, the numerical importance of measures addressing (Support for risk capital’ was relatively limited (7% of measures). However, the range of measures supporting innovation financing is broader including also horizontal measures in support of financing (6%), fiscal incentives in support of the diffusion of innovation (4%) as well as indirect tax incentives and guarantees (3%).

Surprisingly given the increasing identification in policy documents of human resources for innovation as a bottleneck, the range of measures targeting training and mobility for R&D and innovation seems relatively under-represented in the overall STI policy mix. This is particularly noticeable in terms of the relative importance of measures addressing the skills and availability of innovation staff in enterprises (that is, measures likely to contribute to reducing the gravity of ‘capability failures’): ‘recruitment of skilled personnel in enterprises’ and ‘job training of researchers and other personnel involved in innovation process’ (both 4%). However, compared to 2008, the share of the number of measures addressing more specifically ‘researchers’ has increased: ‘*mobility of researchers*’ (from 6.4% in 2008 up to 9% in 2009); ‘*career development, including long term contracts for university researchers*’ (from 4.8% to 6%); ‘stimulation of PhDs’ (from 6% to 7%). In contrast, there has been a slight decrease in the relative importance of measures aimed at inter-linkages between enterprises: ‘*Cluster framework policies*’ (from 9.4% to 7%), ‘*Support to technology transfer between firms*’ (from 8.2% to 7%), ‘*Support to sectoral innovation in manufacturing*’ (from 9.2% to 8%).

As might be expected, the overall picture changes when the policy mix is analysed at a disaggregated level with a focus on countries with different levels of development. Analysis at the level of EIS country groups reveals some substantial variance in terms of policy priorities addressed by national STI policies.

As Figure 7, highlights, while R&D cooperation is the key policy priority for all EIS groups, the focus on this priority among innovation leaders (40% of all measures) is significantly stronger than in any other group. Similarly, the shares of other priorities related closely to science policy (such as strategic research policies, public research organisations and support to excellence and management of research in Universities) are relatively higher in innovation leaders.

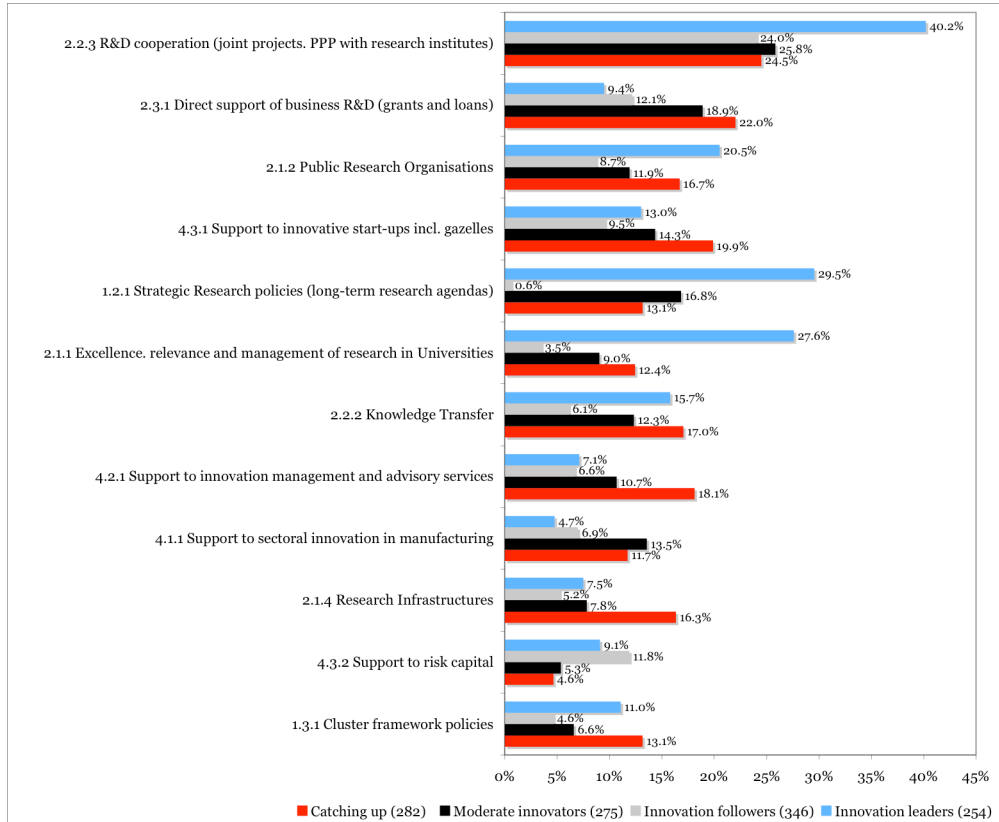
On the other hand, innovation leaders focus much less on providing direct support for business R&D (9%) and support to innovation management services (7%) which are more present in the catching-up countries and moderate innovators (respectively for direct support to R&D 20% and 19% and innovation management 16% and 11%). As expected, given their level of S&T development, catching-up countries give more emphasis to research infrastructures (15% of all measures) than any other group.

Interestingly, both innovation leaders and the catching up group give relatively the same emphasis to measures targeting knowledge transfer (respectively 16% and 17% of their measures) and to the horizontal cluster policies (11% and 13%). Followers and moderate innovators have much lower shares in these categories (apart from 12% share of knowledge transfer measures in moderate innovators).

Innovation followers stand out in their emphasis on the support to risk capital (12%) compared to 9% share of innovation leaders and significantly lower shares in case of moderate innovators and catching countries (about 5% each). Moderate innovators behave similarly to catching up countries with the exception of research infrastructures and cluster framework policies (8% and 7%) where they have less

relevant support measures. On the other hand they place more emphasis on research strategic policies (17% compared to 12% in catching countries).

Figure 7: Key policy priorities in the EIS country groups (2008)



Source: TrendChart-ERAWATCH database; analysis Technopolis Group (N=1157)

Note: Percentages refer to the share of support measures addressing a given policy priority within EIS country group. A single support measure can be assigned up to four policy priorities. The numbers in the legend indicate the total number of measures belonging to the EIS group. The chart includes: (1) 10 policy priorities addressed by the highest number of support measures and (2) 10 priorities with the highest variance between the smallest and biggest share of measures between EIS groups. The most often occurring priorities are the top ten priorities in the exhibit. The priorities with highest variance were (starting with a priority with the highest variance): 1.2.1, 4.2.1, 2.1.4, 2.2.2, 4.3.1, 2.3.1, 2.1.1, 1.3.1, 2.1.2 and 4.3.2.

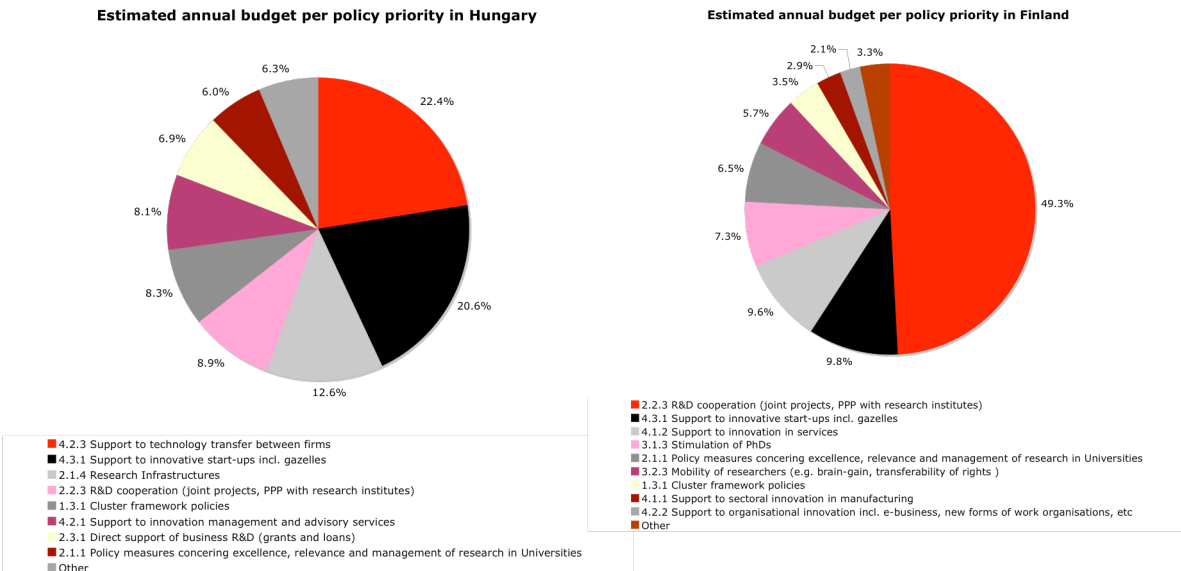
In general, the analysis suggests that innovation leaders concentrate on a smaller number of STI policy priorities than other countries with four key priorities addressed by more than 20% of their measures. Innovation followers have the most diverse policy mix in terms of priorities addressed with just one policy priority above 15% share of all their measures. Moderate innovators and catching up countries seem to have a more horizontal approach with a focus spread more evenly among different priorities.

However, the overall picture would be likely to change if the policy mix was analysed using the budgetary dimension. With a view to the EIPR 2009 (forthcoming January 2010), a detailed analysis of budgetary data for the STI support measures in the TrendChart database is being conducted. This exercise is clearly important since in the context of the 2008 financial crisis, and subsequent pressures on Government budgets, twinned with the on-going commitment of the EU27 to improve their innovation performance, obtaining an estimate of the extent of public funding for innovation and its share between different types of policy measures would enable a more sophisticated analysis of potential impacts of policy on national innovation systems to be developed. Equally, it would enable a refinement of the analysis of the

way in which different countries, at different stages of development or with different intensities of system failures are developing differentiated policy approaches.

At the present time, the data collected on budgetary resources allocated to each measure in the TrendChart database remain difficult to a) collect²⁸ b) aggregate (for a period, between priorities, etc.).

Figure 8: comparison of budget share for STI policy in Hungary and Finland



Source: TrendChart database (data extracted July 2009), calculations Technopolis Group

Figure 8 provides an example of the work in progress by comparing two countries with significantly different levels of innovation performance and innovation systems. Whereas funding for R&D co-operation dominates in Finland (reflecting no doubt the range of collaborative programmes put in place by Tekes), the Hungarian policy mix as defined by budget shares is more varied with a stronger emphasis on technology transfer (logical from the point of view of a country in a catching up phase where internal capabilities of firms need to be boosted) and research infrastructures (again coherent with catching up countries need to put in place the foundations of a more advanced R&D production effort). Finland on the other hand makes a relatively important investment into innovation in services (coherent with the policy emphasis placed on this in Finnish strategies and the growing importance of the service sector in this more advanced economy). Both countries place importance in budgetary terms on

The on-going analysis will aim to build on such budgetary figure to produce a first estimate of the current (2007-13) average annual budgets for STI policies in the EU27 broken down by EIS groupings. ‘Fact-sheets’ per country providing comparative analysis (against EU27 averages) of the data on the beneficiaries (SMEs vs individuals vs research organisations, etc), targeted technology fields, funding sources (Structural

²⁸ As the draft 2009 Finnish TrendChart country report notes “Annual budgets of the policy measures are very difficult to obtain from the agencies and policy makers, and the main innovation policy agencies, such as Tekes, do not differentiate annually the amount of spent money on specific instruments in their annual reviews or other official documents. Only a minority of the Finnish measures reveal the annual budget data, which does not allow us to make comparative analyses. Total budgets of the measures are more readily available but the database consists of on-going measures and fixed-term measures which make the comparison problematic”.

funds, private co-financing, etc.) have been made available to the TrendChart country report authors and it is hoped that such aggregate analysis will be made available in coming years in dynamic form to public users of the TrendChart service.

Of course, not all innovation measures are ‘financial’ in nature (providing funding directly or indirectly to actors in the NIS) and regulatory or legislative interventions could be as important as State aid for R&D projects or tax credits. Again, here the development of a more detailed analysis of the expected outcomes of measures in a national policy mix would enable a ranking of the relative importance of financial versus non-financial measures in targeting and alleviating failures in national innovation systems.

5. Conclusions

The three key messages emerging from the evidence accumulated by the TrendChart project on the policy challenges and responses (policy measures) of the EU27 Member States are as follows:

- Challenges for innovation policy differ across the Member States depending on the level of economic development, performance of their innovation systems and the ‘maturity’ of innovation policies. While challenges addressing ‘capability failures’ are the most dominant for the EU27 as a whole; the Member States in the innovation leaders group give much more emphasis to framework failures. This does not imply that the leaders have weaker frameworks for innovation, but rather a shift to a broader understanding of innovation drivers in their economies.
- Concerning the policy-mix and the extent to which it targets specific market or innovation system failures, the moderate innovators and catching-up countries give much more emphasis to direct support to companies (‘capability failures’), including advisory services and technology diffusion; while the policy-mix in the more advanced countries gives much more emphasis to network failures (possibly reflecting the earlier shift to clusters and joint industry-academia R&D co-operation programmes).
- In terms of the correspondence between challenges and the policy response, it appears that while catching-up countries and moderate innovators recognise that they face significant ‘institutional failures’, the policy response in these countries with respect to this type of challenge remains rather limited. For innovation leaders, there seems to be a discrepancy between the importance given to network failures in the identified challenges and the actual policy response (where it is the most prevalent policy failure).

Further work on analysing innovation policies needs to enrich this analysis by understanding a) the targeting of different instruments of innovation policy on ‘individual agents’ (SMEs, etc.) versus measures aimed at improving wider ‘ecosystems’ b) the relative weight of financial investments made by the public sector in pursuit of different policy priorities and their correspondence with the level of development of different national innovation systems in the EU27; c) the extent to which ‘narrow innovation policy’ is interacting with other policy fields to tackle the social (poverty, ageing, etc.) and ‘grand challenges’ (climate change, energy consumption, resource efficiency, etc.) d) the extent to which non-financial measures are being used to tackle, notably, institutional, framework and governance failures, including in less-advanced innovation systems where such failures are claimed to be more significant barriers to innovation.

References

- Aho E. et al (2006). Creating an innovative Europe, Report of the Independent Expert Group on R&D and Innovation. http://ec.europa.eu/invest-in-research/pdf/download_en/aho_report.pdf (consulted 19/1/09)
- Cowan R. and van de Paal G. 2000, Innovation Policy in a knowledge-based economy. MERIT for Directorate-General for Enterprise, European Commission, Brussels. ftp://ftp.cordis.europa.eu/pub/innovation-policy/studies/studies_knowledge_based_economy.pdf
- Duchêne, V., Lykogianni, E. and Verbeek, A. (2008) The EU-US R&D under-investment: patterns of R&D expenditure and financing”, in Soete, L. (ed.), The European Research Area: the way forward, Edward Elgar publishing.
- Edler, Jakob et al (2005) “Innovation and Public Procurement – Review of Issues at Stake”, Study for the European Commission ENTR/03/04.
- Freeman C. (2006) Catching up and innovation systems: implications for Eastern Europe; in In K. Piech and S. Radosevic “Knowledge based economy in central and eastern Europe: countries and sectors in process of change”.
- Georghiou L. (2007) “Demanding Innovation: Lead markets, public procurement and innovation” NESTA, London
- Lundvall B-Å and Borrás S (2005) Science, technology and innovation policy; in Fagerberg J, Mowery D.C. and Nelson R. (Eds.) (2005); The Oxford Handbook of Innovation
- Malerba F. (2005) Sectoral Systems: how and why innovation differs across sectors. In Fagerberg J, Mowery D.C. and Nelson R. (Eds.) (2005). The Oxford Handbook of Innovation.
- Metcalf J.S., 2005, ‘Systems Failure and the Case for Innovation Policy’, in P. Llerena and M. Matt, Innovation Policy in a Knowledge Based Economy, Springer, Berlin.
- Nauwelaers C. et al (2009). Final Report of the Policy Mix Study.
- OECD (2005) The Oslo Manual: guidelines for collecting and interpreting innovation data. Third edition. <http://213.253.134.43/oecd/pdfs/browseit/9205111E.PDF>
- Porter, M. 1990. The Competitive Advantage of Nations. New York: The Free Press.
- Radosevic S. (2006): The Knowledge Based Economy in Central and Eastern Europe: an overview of key issues. In K. Piech and S. Radosevic “Knowledge based economy in central and eastern Europe: countries and sectors in process of change”.
- Radosevic S. Reid A. (2006): Innovation policy for a knowledge based economy in Central and Eastern Europe: driver of growth or new layer of bureaucracy? In K. Piech and S. Radosevic “Knowledge based economy in central and eastern Europe: countries and sectors in process of change”.
- Rostow, W. W. 1960. The Stages of Economic Growth, a Non-Communist Manifesto. Cambridge: University Press.
- Tidd J. Bessant J. Pavitt K. (2005) Managing Innovation: integrating technological, market and organizational change (3rd Edition).
- Tsipouri L, Reid A. Miedzinski M. (2008) European Innovation Progress Report 2008. Directorate-General for Enterprise Policy, European Commission, Brussels.

Petri Peltonen*

The economic recession and future growth challenge innovation policy

Until recent years, Finland has succeeded well in international comparisons of education, research and technology, being one of the leading nations in terms of research, innovation activity and the quality of its business operating environment. Finland's success has been largely based on its high quality educational system, long-term investments in research and development by enterprises and the public sector alike, and well-functioning cooperation between trade and industry, research institutions and the public sector in various areas of innovation activity.

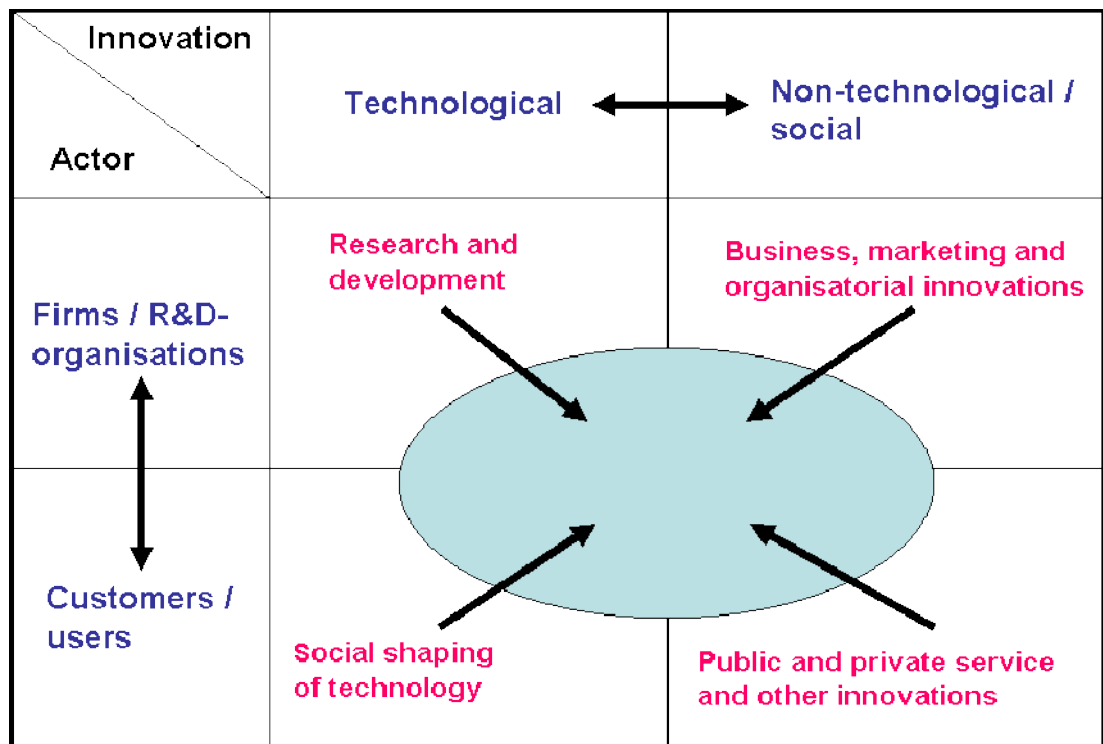
The position of a pioneer requires renewal

However, previous success is no particular guarantee of what lies ahead. Due to globalisation, competition is intensifying rapidly in the worldwide, borderless operating environment of innovation activity. Moreover, the international financial crisis is heavily transforming current lines of business, changing the international division of duties, and accelerating structural change. In effect, many of our current competitive advantages are being challenged.

Hence, Finland's success in international comparisons evaluating competitive ability and the development of the information society has been on the decline. This forces us to consider, critically and without bias, our competitive position, while motivating us to pursue new opportunities arising from the changes in the economy, society and the global operating environment.

Finland's long-term investments in expertise and technological research and development have produced good results, and a successful science and technology policy has created the basis for many successful industries. This provides a sound platform for building the future. However, the challenges presented by growth and competitiveness can no longer be tackled solely by means of a sector-based, technology-oriented strategy. In line with the national innovation strategy, innovation activity must be developed to cover a broader spectrum in terms of its contents, and to operate with a more user-oriented approach. The Research and Innovation Council illustrates this change in its policy report of December 2008, as shown below.

* The author is Director General at the Innovation Department of the Ministry of Employment and the Economy, Finland



Expanding innovation activities: new interactions between players and functions (Research and Innovation Council of Finland, policy report 2008).

Towards broad-based innovation activity

The national innovation strategy, completed in 2008, defines innovation as an exploited, competence-based competitive asset. Successful innovations are usually based on the open-minded combination of various competencies, while too narrow a concept of innovation activity results in part of innovation potential remaining untapped.

A broad-based innovation concept introduces other intangible investments, in addition to research and development activities, into the sphere of innovation activity and the advancement of systematic development. These include business concepts, service models, brands, organisational structures and operating methods. In terms of contents, as part of innovations, expertise beyond technological expertise is exploited, such as product design, business economics, and behavioural, cultural, health and social sciences.

Broad-based innovation activity facilitates the formation of new strengths, well suited to Finland. Well-functioning cooperation structures and low borders between enterprises, universities, research institutions and the public sector provide sound preconditions for diversified, competence-based reform efforts. Likewise, stronger linkage of creative sectors

as part of innovation activity – for example the Aalto University – would open up new opportunities for Finland.

Public innovation funding in Finland encourages cross-border cooperation and, to an increasing extent, multiform innovation activity exploiting both technological and non-technological expertise. This creates the preconditions for diversifying our innovation activities and reinforcing future competitiveness in a situation where international competition is about to overtake us in many traditional research and technology development sectors.

Demand and user orientation as a basis for innovation activity

Innovation activity no longer abides by the traditional logic of invention. Instead of searching for customers for new inventions, in an increasing number of cases new solutions are being sought for customers. In a world where the majority of technologies is available on the markets, competitive strength is often based on the ability to realise the needs of customers, consumers and citizens before competitors do, and to offer corresponding products and services. Around the world, leading edge companies are involving consumers and customers in product development. Enterprises are even processing previously unrecognised needs together with users, thus influencing the emergence of a completely new kind of market. Various forms of open and public innovation activity are gaining ground alongside traditional, closed innovation activity. Policies must therefore create the preconditions for the emergence of open innovation environments.

In Finland, innovative enterprises cooperate with customers to a greater extent on average than in many other EU countries. Innovation activity is market-oriented innovation that seizes the opportunities presented by the markets. Value chains are being steered from customers and consumers towards producers and developers rather than vice versa. Innovation policy must adapt to this change in innovation activity and accelerate its pace. Attention must be paid to the quality and depth of cooperation, and the creation of markets for innovative solutions must be promoted.

Traditional innovation policy has focussed on the development and commercialisation of new technologies. Even the success of innovation policy has been measured primarily with the help of development investments and technological output. In the future, innovation policy will place a greater emphasis on the development of products and services meeting the needs of customers, and the strengthening of users' and developers' mutual development work. There is room for improvement in Finland, for instance as concerns the development and introduction of user-oriented service innovations. Particular attention should also be paid to enhancing the productivity of the public sector through the development of competence-based services and service capabilities.

Individuals and communities create innovations

Ultimately, the production of innovations depends on individuals. However, innovations do not usually happen by chance. Instead, innovativeness is linked to clear objectives and problem-setting. Innovation requires systematic working with the problem and a sufficient quantity of information on the phenomenon, customers, technologies, patents, previous solutions and operating modes etc. Innovations also require a division of duties, and sufficient time and space reserved for innovators, which, in turn, poses new challenges for organisational structures and management.

Innovations and entrepreneurship are closely connected. In many cases, entrepreneurs are those who are able to combine ideas, the ability to take risks and other required skills with a clear view of customers' needs. Innovation policy must be entrepreneurship policy - a key viewpoint to consider when reforming public services. In Finland, entrepreneurship activity has been found wanting, and its development calls for measures that also pay attention to the novel attitudes of new generations towards entrepreneurship.

An operating environment fruitful in terms of innovations is one where individuals with different backgrounds work with the same problems. Innovative communities can be tight-knit teams that meet on a daily basis, or more loosely coupled communities working as a network. The success of innovative communities is based on sharing competence and knowledge, and the ability to combine various perspectives and approaches. Increasingly often, innovations are created at the interfaces of various competence areas.

Innovation communities and centres are increasingly international. When knowledge and communication technology is utilised, global knowledge communities are formed with members from any part of the world. Enterprises, too, are increasingly resorting to open communities in innovation activity.

International examples indicate that innovation activity is being centralised and is finding its way to regions and localities offering sufficient preconditions for innovation activity. Instead of national innovation systems, innovation ecosystems and innovation centres are drawing attention, being locally and regionally fixed but globally networked at the same time. They combine, in a fruitful manner, needs and ideas with the abilities required to implement the latter. The dynamics of such ecosystems are based on communities where the prevailing culture favours cooperation, knowledge, the sharing of ideas and willingness to take risks.

We in Finland must find a way, suitable for our conditions and capitalising on our strengths, to create globally networked innovation activity ecosystems. By international standards, Finland boasts exceptionally close links between information providers and users. On the other hand, we are falling below par in several areas. For example, we lack the top-class services required to commercialise ideas rapidly and create new start-ups. Capital investors who ensure the rapid growth of start-up firms with sufficiently large investments operate in successful ecosystems. Another group of significant operators are business angels, who

place their wealth of experience and networks at entrepreneurs' disposal. In these respects, Finland is lagging behind international trends.

Renewed innovation activity will address the challenges presented by the economic recession

Finland has relatively recent experience of a severe economic recession: we surfaced rapidly after the difficulties experienced in the early 1990s to embark on new growth thanks to determined investments in research and new technology. Close and well-functioning cooperation between universities and enterprises developed into one of the strengths of Finnish innovation activity, gaining international recognition.

However, the mere reapplication of the formulas which succeeded in the 1990s will not suffice today, since the operating environment for enterprises and universities knows no borders. Now, both the determined maintenance of private and public investments in research, product development and innovation activity, and the unbiased modernisation of innovation activity contents and operating modes are called for. The contents of the development guidelines listed in the innovation policy report correspond fairly well with the needs of innovation activity, even in financially challenging times.

Incentives and funding: Public funding is assuming an increasingly important role as an incentive for maintaining research, product development and innovation activity during the economic recession. As a consequence of the weakening financial situation, the time span for innovation activities in enterprises is becoming shorter, and the ability to take risks is diminishing. There is the threat of declining investments in longer-term, higher risk research and product development activities. The recession is also reflected in research projects financed by enterprises in universities and research institutions, which create knowledge capital for enterprises' long-term competitive strength and new business operations. This close cooperation between business life and academic research is a particular strength of Finnish innovation activity. It is therefore vital that this core strength does not suffer as a consequence of the recession.

Demand and customer orientation: The economic recession is inexorably reducing demand, but it is also creating new needs as value chains change and enterprises modify their operating models and subcontractor structures while outsourcing operations. Furthermore, the significance of services as the basis of both business and innovation activity is being emphasised. As the recession intensifies structural change, the companies which are the first to predict changing customer needs and develop solutions thereto will be successful. In this operating environment, the openness, speed and agility, and even the cost-efficiency, of demand-based and user-oriented innovation activity will be emphasised as benefits parallel to companies' own internal research and product development activity.

Diverse innovation activity: As competition intensifies and the financial situation becomes more severe, speed and economic efficiency are expected from the operations of enterprises and value chains. More broad-based and diverse innovation activity entails even the exploitation of small-scale, streamlined development measures. An open-minded combination

of existing technological and non-technological expertise with service and operating models, as well as work and production processes, will allow enterprises to modify product portfolios quickly while enhancing productivity and cost-efficiency.

Competence base for new growth: Major drivers of change, such as globalisation, ageing and climate change are reshaping the world, creating new needs and transforming many of the current operating methods and lines of business and industry. Likewise, the market revival after the economic recession will open up opportunities for entirely new business operations and a significant redistribution of market shares. All of this requires a solid knowledge base in key sectors for the renewal of trade and industry and the development of Finnish society. In addressing these challenges and opportunities, the new Strategic Centres of Excellence for science, technology and innovation (SHOKs), national programmes implementing new expertise in practice (Tekes, Centre of Expertise programme OSKE) and Finland's integration into European and international research programmes and networks, will play an increasingly important role.

References

- Government's Communication on Finland's National Innovation Strategy to the Parliament 2008, www.tem.fi/inno
- Research and Innovation Council, policy report 2008, www.minedu.fi
- International Evaluation of the Finnish National Innovation System, www.evaluation.fi

The challenge of sustainable innovation policy

Marko Hekkert

Department of Innovation and Environmental Sciences
Utrecht University, The Netherlands

Abstract:

This paper raises questions by the sustainability of economic growth. It states the need for a more sustainable growth direction and it makes the point that this can not be reached by traditional innovation policy. A new perspective is needed that is based on stimulating the formation of specific sustainable innovation systems. The consequences of this perspective are explained.

Introduction: what is the problem?

The basic observation that guides this position paper is that our current direction of economic development is not sustainable. This awareness is becoming more and more mainstream due to the climate problem. Ten years ago the climate change was also seen a serious environmental problem, but the uncertainties about its causes and effects were so high that the impact on policy makers was still modest. Now that consensus about the impact of our economic activities on the climate is growing and the pace of climate change is much higher than previously expected, the urgency to change our way of creating economic value is becoming evident.

The climate change problem is strongly related to our energy consumption patterns. In order to bring down the threats of climate change to acceptable proportions, global CO₂ emissions must be cut down by 80 per cent roughly by 2050. This will require a complete transformation of the energy sector. The technological knowledge required to greatly reduce carbon emissions exists already ¹, but transforming the energy system into a sustainable one will require an effort of change beyond anything that we have witnessed so far. The prime reason for this is that our energy consumption patterns are strongly related to almost any economic activity that we can think of. Almost all economic processes require energy or require materials that require energy in their production process. The necessary transformation of the energy systems is therefore almost equal to a transformation of our complete production and consumption system.

This strong interdependency makes the climate change problem different from any environmental problem that we have encountered so far. Acid rain, ozone layer decline and water pollution could all be fixed with relative simple technological solutions and the necessary policy initiatives only affected parts of the economy.

So what is necessary in the next decades is a shift in goals and practices of innovation underlying economic growth. Instead of developing technologies and processes that purely add economic value, products and processes are needed that add both economic value and contribute to a low carbon economy. Just stimulating the pace of innovation is already a challenge, but also changing direction of innovation into a more sustainable direction is even harder.

I will point to three particularly important sources of obstacles that makes this change in direction so difficult¹:

1) Initially, new sustainable technologies tend to be more expensive and have lower performance measured along some dimensions than existing technologies. This is often the case with new technologies but there are normally applications/segments that still demand the new technology if it is superior in some performance dimension. New energy technology is, however, characterized by providing society at large with benefits (reduced emissions) whereas the initial high costs are borne by the individual customer. There are, thus, free rider problems, because sustainability has a strong collective good character. This feature is a powerful obstacle to the formation of markets. Nevertheless, the build up of new markets is important in order to stimulate firms to move into the new technologies², to enable user-producer interactions to develop^{3,4} as well as allow for the articulation of user preferences and other learning processes⁴.

2) Existing technologies and sociotechnical systems are protected by strong lock-in mechanisms⁵. Long periods of increasing returns on investments (e.g. learning by doing and using, scale economies, network externalities) often put them in an advantageous position. Also standards and aligned regulations provide existing technologies with stability. Large firms have sunk investments (in capital, competencies, social networks) that give them strong vested interests in maintaining established technologies. Industry associations and special-interest groups lobby policy makers for support (e.g. massive subsidies for coal) and continued favourable regulations. Also users may contribute to stability, especially when particular technologies have been integrated in their life styles and behavioural patterns. The stability of existing sociotechnical systems provides barriers for (some) sustainable technologies, especially when they face a 'mismatch' with the existing system⁶. There is simply no 'level playing field' when existing technologies are subsidised and protected by favourable regulations.²

¹ These points are taken from ²⁴

² Additionally, some technologies, such as hydrogen, cannot compete in the absence of new infrastructures.

3) Uncertainties about future market demand, infrastructure investments, and regulations hinder actors to commit to the development of sustainable technologies. Many large energy and transport firms already make substantial R&D investments in sustainable technologies (e.g. Toyota in hybrid cars, Ford in fuel cell cars). But most of the innovations remain on the shelf or are paraded on demonstration shows. On the one hand, large firms obviously have vested interests and fears of cannibalising their existing products. On the other, there are still many uncertainties that prevent commitment. Hence, large firms in Europe and the US are increasingly asking governments to provide more clarity and certainty. Under normal circumstances one would expect small entrepreneurial firms to reap the benefits that come from slowly changing incumbent firms. Smaller firms who enter new technological fields and markets are often more flexible in dealing with uncertainties than large incumbent firms. Also they have much more to gain since their current market share is zero and the promise of a large market share is in sight. This explains why many radical innovations come from new comers. However, due to the strongly regulated character of the energy sector, normal market dynamics do seldom take place. Incumbent companies have a large influence in the political debates and decisions regarding any change in the energy sector. Smaller entrepreneurial firms hardly have any lobby power that is necessary to create favourable conditions for their innovations. The success rate of these firms is therefore much smaller than under normal market conditions.

To overcome these obstacles we need a different form of innovation policy than has been used so far. In the next section I will explain the traditional policy view on tackling the problems stated above and then I will discuss the change in policy practice that is necessary.

Traditional policy views on creating a sustainable innovation direction

The drastic transformation of the energy, industrial and consumption system can not be reached by doing things slightly different. New product and service innovations need to be developed that have a much lower impact on our climate. Up till now, changing the current direction of innovation into a more sustainable direction has not been part of innovation policy. Most efforts in this direction are made by environmental and energy policies.

Environmental policy in the past has focused heavily on stimulating the adoption of all kind of process innovations that lead to cleaner production processes that use less inputs from the natural environment and produce less harmful emissions. Typical instruments to reach these kinds of objectives are legislation (e.g., setting maximum emission standards), economic instruments (e.g., price penalties on emissions) and voluntary agreements (e.g., agreements with industries to cut down emissions). The innovation activities that are necessary to develop these process innovations are often not the focus of environmental policy. In the environmental policy literature there is a fierce debate whether the so-called Porter Hypothesis (where Michael

Porter and Claas van der Linde state that environmental regulation is likely to have a positive effect on economic competitiveness of firms and innovation) is true or not.

Thus, stimulating sustainable product innovations is generally not part of environmental policies. Energy policies on the other hand have focused on stimulating the development of alternative energy technologies. Only in a few countries (like Germany) this has resulted in successful results. In most countries the share of renewable energy is quite low. In the Netherlands for example, 20 years of renewable energy policy has led to a dramatically low renewable energy share of 3% in 2008. The main instruments that have been used to reach this disappointing result are the support of R&D and market creation programs. The rationale for the latter instrument is that renewable energy technologies can not compete with conventional energy technologies under normal market conditions and therefore need financial support.

At Utrecht University we analysed several historical developments of renewable energy technologies in The Netherlands to find out why the stimulation of energy innovations proved to be so problematic. Examples of technological trajectories that we analysed are solar energy, first and second generation biofuels, biomass digestion, biomass gasification, biomass combustion, and combined heat and power⁷⁸⁻¹⁷. The story of all these developments is different. But what stands out is the following:

1. There is a big gap in the policy instrument portfolio between R&D stimulation and market creation programs. Very few instruments were in place to support technologies that are past the R&D phase and yet not ready to enter the market. The so-called valley of death proved difficult to cross.
2. The attention of policy makers for specific energy innovations fluctuated strongly over time. In some periods technology A received much attention while in a later period this attention was shifted to a newer and more promising alternative B. For many technologies we witnessed strong fluctuations in expectation dynamics.
3. Related to this is the observation that the policy instruments that were used to stimulate energy innovations changed frequently over time. R&D subsidies were granted for limited periods of time and market stimulation programs frequently stopped and started again under different conditions.
4. There was a strong focus on technologies that could deliver high reductions in carbon emissions against lowest costs. There was hardly attention for the potential benefits of the energy innovations to economic indicators like employment, GDP growth and export. Thus: energy technologies were always seen through an 'environmental lens' and not through an 'innovation lens'.
5. Technology development and innovation were expected to be short term processes. Investments in R&D were expected to lead quickly to market ready technologies. Disappointments about the timeframes often led to attention shifts to alternative trajectories.
6. There was a strong focus on learning by searching (R&D) and very limited attention for learning by doing. This became evident in the technology choices

(high tech technologies in R&D phase were preferred over more simple technologies that were market ready) and in the lack of instruments that are in between the R&D phase and market phase of the innovation process.

7. There was very little attention for the exchange of knowledge and the build up of innovation networks.

To sum up the above: Innovation policy is for the major part focused on creating economic growth and sustainable development does not play a big role. The few innovation policy efforts that are focusing on sustainable development are often not very successful due to a fact that policy interventions are still strongly linear model based.

In the next session I will explain the policy view that is necessary to transform the energy sector in a more sustainable one and I believe this holds more generally for transforming our whole economy in a more sustainable direction.

Thinking in terms of emerging innovation systems

The theoretical perspective that we take at the innovation studies group in Utrecht on the development of emerging technologies is the innovation system perspective. We start from the position that around each energy innovation a specific innovation system needs to be build up. We label these as technological innovation systems¹⁸. Contrary to much of the work on National Innovation Systems that analyse innovation systems that are already in place, for these technological innovation systems it is necessary to understand the formation process^{19, 20}.

This formation process is a very delicate and long lasting process due to the three obstacles for successful innovation that I described in the introduction. During the formative stage of an emerging innovation system knowledge and technologies are developed, networks are build, capital and actors are drawn in, legitimacy for the new technology is build up and early markets are developed²¹. This formative stage is necessary before the innovation system is developed enough to shift to the growth phase where technology diffusion takes place¹⁹.

The transformation process of the energy sector viewed from this perspective is a process where several technological innovation systems emerge, grow and at a certain point are developed enough to be able to compete with the established and locked in energy system. Some of these emerging innovation systems will then succeed in becoming part of the energy system and by this the transformation process takes place.

We do not now in advance which of these technological innovation systems will become successful, so it is necessary to support a range of emerging innovation systems. The type and number of innovation systems supported by a country is likely

to be related to the size of the country and the local competences and resources that are present.

The formation process of many technological innovation systems are studied based on historical analyses and reported in the scientific literature. Based on these analyses insight is created in the key processes that need to take place in the emerging innovation systems to successfully go through the formative phase. In different studies, slightly different lists of key processes are mentioned but the overlap between the insights is very large. Below I present the set of key processes that we use in Utrecht as the most important processes that need to take place for an innovation system to develop (taken from ²²). These key processes are called the 'functions of innovation systems' as these processes are required to be performed in the innovation systems.

Function 1: Entrepreneurial activities

There is no such thing as an innovation system without entrepreneurs. Entrepreneurs are essential for a well functioning innovation system. The role of the entrepreneur is to turn the potential of new knowledge, networks, and markets into concrete actions to generate - and take advantage of - new business opportunities. Entrepreneurs can be either new entrants that have the vision of business opportunities in new markets, or incumbent companies who diversify their business strategy to take advantage of new developments.

Function 2. Knowledge development

As mentioned above, mechanisms of learning are at the heart of any innovation process. For instance, according to Lundvall: "the most fundamental resource in the modern economy is knowledge and, accordingly, the most important process is learning"³. Therefore, R&D and knowledge development are prerequisites within the innovation system. This function encompasses 'learning by searching' and 'learning by doing'.

Function 3. Knowledge diffusion through networks

According to ¹⁸ the essential function of networks is the exchange of information. This is important in a strict R&D setting, but especially in a heterogeneous context where R&D meets government, competitors, and market. Here policy decisions (standards, long term targets) should be consistent with the latest technological insights and, at the same time, R&D agendas should be affected by changing norms and values. This way, network activity can be regarded as a precondition to 'learning by interacting'. When user producer networks are concerned, it can also be regarded as 'learning by using'.

Function 4. Guidance of the search

Since resources are almost always limited, it is important that, when various technological options exist, specific foci are chosen for further investments. Without this selection there will be insufficient resources left for the individual options. This

function can be fulfilled by a variety of system components such as the industry, the government, and/or the market. When knowledge creation (function 2) is regarded as the creation of technological variety, this function represents the process of selection. Also, from a societal stance, guidance of the search is an important activity. Where functions 2 and 3 referred to mechanisms of learning, without discussing the direction of the learning process, guidance of the search indicates that technological change is not autonomous. Changing preferences in society, if strong and visible, can influence R&D priority setting and thus the direction of technological change.

As a function, guidance of the search refers to those activities within the innovation system that can positively affect the visibility and clarity of specific wants among technology users.

Function 5. Market formation

New technology often has difficulty to compete with embedded technologies. Rosenberg (1976) puts it like this: "Most inventions are relatively crude and inefficient at the date when they are first recognized as constituting a new innovation. They are, of necessity, badly adapted to many of the ultimate uses to which they will eventually be put; therefore, they may offer only very small advantages, or perhaps none at all, over previously existing techniques. Diffusion under these circumstances will necessarily be slow". Because of this, it is important to create protected space for new technologies. One possibility is the formation of temporary niche markets [49] for specific applications of a technology. Within such an environment actors can learn about the new technology (function 2 and 3) and expectation can be developed (function 4). Another possibility is to create a (temporary) competitive advantage by favorable tax regimes (e.g., the Dutch experience with reducing taxes for renewable energy) or minimal consumption quotes (e.g., the German feed-in law for renewable energy).

Function 6. Resources mobilization

Resources, both financial and human capital, are necessary as a basic input to all activities within the innovation system. For a specific technology, the allocation of sufficient resources is necessary to make knowledge production possible. In this sense, this function can be regarded as an important input to function 2.

Function 7. Creation of legitimacy / counteract resistance to change

In order to develop well, a new technology has to become part of an incumbent regime, or it even has to overthrow it. Parties with vested interests will often oppose to this force of 'creative destruction'. In that case, advocacy coalitions can function as a catalyst; they put a new technology on the agenda (function 4), lobby for resources (function 6) and favorable tax regimes (function 5), and by doing so create legitimacy for a new technological trajectory²³. If successful, advocacy coalitions will grow in size and influence; they may become powerful enough to brisk up the spirit of creative destruction. The scale and successes of these coalitions directly depend on the available resources (function 6) and the future expectations (function 4) associated with the new technology.

These key processes are not independent processes. In fact they strongly influence each other. The interaction between the system functions leads to cumulative causation processes¹⁷. These processes strongly accelerate the build up of innovation systems when the interaction is positive but they may also stall the development due to negative interactions.

Implications for policy making

Sustainable innovation policy that is based on stimulating the formation of a range of specific technological innovation systems is quite different from traditional innovation policy.

First, it is necessary to focus on specific technological systems which require specific policy measures for each technological innovation system. Differences in policy needs are determined by the phase that the innovation system is in, the specific problems related to the technology, acquisition of financial resources, distance to market, strength of the networks, international playing field, etc. This implies that one policy for all is not likely to work. The consequence is that innovation policy makers need to create a feeling for the specific circumstances in individual innovation systems and for the specific problems that are related to specific technological fields. This implies that innovation policy makers need to be much better trained in the technological fields for which they are responsible.

Second, it is necessary to develop a consistent and long term policy to stimulate the formation of new innovation systems. Ad hoc policy initiatives increase uncertainties for the entrepreneurs, engineers, venture capitalist and other actors in the innovation system that decreases the success chances of innovation system development. Long term and consistent policy does not mean that policy instruments can not change over time. In fact, due to the changes in the needs of the actors in the innovation system, a continuous reflection on the effects of policy measures on the innovation system and subsequent alteration is necessary.

Third, it is necessary to listen more carefully to new entrants and often small innovative firms. This is not a easy task since most lobby networks are dominated by large incumbent firms. New entrants often find large obstacles when trying to enter these lobby networks. Their message is therefore not easy to hear. Moreover, when policy instruments are designed in favor of these emerging innovation systems, fierce opposition can be expected from the old regime. The Dutch experience show that policy makers have a strong preference to keep lobby networks in place by trying to persuade the incumbents firms to develop sustainable innovations. Very often, new entrants are not at the table when new policy measures are designed.

Fourth, next to stimulating novelty, it is necessary to put pressure on the incumbent locked-in system. This increases the success chances of the emerging innovation

systems as the products of these innovation systems have better chances within the old system. In this case the generic policy instruments favored by neoclassic trained policy makers are useful.

Finally, technological innovation systems cross national boundaries. Therefore international cooperation is necessary to effectively stimulate sustainable product innovations.

Thus, contemporary sustainable innovation policy should not focus on isolated interventions directed at individual stages of the linear innovation chain but should consist of a set of instruments that take into account the innovation system characteristics and stimulate the development of innovation systems in an orchestrated way.

References

1. Pacala, S. & Socolow, R. Stabilization wedges: Solving the climate problem for the next 50 years with current technologies. *Science* **305**, 968-972 (2004).
2. Jacobsson, S. & Johnson, A. The diffusion of renewable energy technology: An analytical framework and key issues for research. *Energy Policy* **28**, 625-640 (2000).
3. Lundvall, B. -, Johnson, B., Andersen, E. S. & Dalum, B. National systems of production, innovation and competence building. *Research Policy* **31**, 213-231 (2002).
4. Kemp, R., Schot, J. & Hoogma, R. Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technology Analysis and Strategic Management* **10**, 175-195 (1998).
5. Unruh, G. C. Understanding carbon lock-in. *Energy Policy* **28**, 817-830 (2000).
6. Freeman, C. in *Technology policy and economic performance: Lessons from Japan* (Pinter Publishers Ltd., London, 1987).
7. Alkemade, F., Kleinschmidt, C. & Hekkert, M. Analysing emerging innovation systems: A functions approach to foresight. *International Journal of Foresight and Innovation Policy* **3**, 139-168 (2007).
8. Hekkert, M. P., Harmsen, R. & de Jong, A. Explaining the rapid diffusion of Dutch cogeneration by innovation system functioning. *Energy Policy* **35**, 4677-4687 (2007).
9. Hekkert, M. P. & Negro, S. O. Functions of innovation systems as a framework to understand sustainable technological change: Empirical evidence for earlier claims. *Technological Forecasting and Social Change* **76**, 584-594 (2009).

10. Hillman, K. M., Suurs, R. A. A., Hekkert, M. P. & Sanden, B. A. Cumulative causation in biofuels development: A critical comparison of the Netherlands and Sweden. *Technology Analysis and Strategic Management* **20**, 593-612 (2008).
11. Negro, S. O. & Hekkert, M. P. Explaining the success of emerging technologies by innovation system functioning: The case of biomass digestion in Germany. *Technology Analysis and Strategic Management* **20**, 465-482 (2008).
12. Negro, S. O., Hekkert, M. P. & Smits, R. E. Explaining the failure of the Dutch innovation system for biomass digestion-A functional analysis. *Energy Policy* **35**, 925-938 (2007).
13. Negro, S. O., Hekkert, M. P. & Smits, R. E. H. M. Stimulating renewable energy technologies by innovation policy. *Science and Public Policy* **35**, 403-416 (2008).
14. Negro, S. O., Suurs, R. A. A. & Hekkert, M. P. The bumpy road of biomass gasification in the Netherlands: Explaining the rise and fall of an emerging innovation system. *Technological Forecasting and Social Change* **75**, 57-77 (2008).
15. Suurs, R. A., M.P. Hekkert. Competition between first and second generation technology: Lessons from the Formation of a Biofuels Innovation System in the Netherlands. *Energy – The International Journal* (accepted for publication).
16. Suurs, R. A. A. & Hekkert, M. P. Competition between first and second generation technologies: Lessons from the formation of a biofuels innovation system in the Netherlands. *Energy* (2009).
17. Suurs, R. A. A. & Hekkert, M. P. Cumulative causation in the formation of a technological innovation system: The case of biofuels in the Netherlands. *Technological Forecasting and Social Change* (2009).
18. Carlsson, B. & Stankiewicz, R. On the nature, function and composition of technological systems. *Journal of Evolutionary Economics* **1**, 93-118 (1991).
19. Jacobsson, S. & Bergek, A. Transforming the energy sector: The evolution of technological systems in renewable energy technology. *Industrial and Corporate Change* **13**, 815-849 (2004).
20. Jacobsson, S. & Lauber, V. The politics and policy of energy system transformation - Explaining the German diffusion of renewable energy technology. *Energy Policy* **34**, 256-276 (2006).
21. Markard, J. & Truffer, B. Technological innovation systems and the multi-level perspective: Towards an integrated framework. *Research Policy* **37**, 596-615 (2008).

22. Hekkert, M. P., Suurs, R. A. A., Negro, S. O., Kuhlmann, S. & Smits, R. E. H. M. Functions of innovation systems: A new approach for analysing technological change. *Technological Forecasting and Social Change* **74**, 413-432 (2007).

23. Sabatier, P. A. The advocacy coalition framework: Revisions and relevance for Europe. *Journal of European Public Policy* **5**, 98-130 (1998).

24. Geels, F. W., Hekkert, M. P. & Jacobsson, S. The dynamics of sustainable innovation journeys. *Technology Analysis and Strategic Management* **20**, 521-536 (2008).

‘Picking Winners’ Revisited: Government’s Role in Innovation during an Economic Crisis

Henry Etzkowitz^{1,2} and Marina Ranga^{1,3}

¹ Stanford University, US

² Edinburgh University, UK

³ Stony Brook University, State University of New York, US

“The Keynesian approach should be looked at as a band aid, not a surgical performance.”
(Main, 2009)

Abstract

In this paper, we argue that the current economic crisis is a fault line in the transition from an industrial to a knowledge-based society and is thus potentially subject to a different set of dynamics than previous crises, like the Great Depression of the 1930’s, which occurred within an existing mode of production. Therefore, a qualitatively different response is needed to address the current downturn – one that ensures that the recovery is durable and sustainable. Keynesian methods aimed to recover from a downturn in an industrial economy are no longer sufficient for a downturn in the transition to a knowledge-based economy. Large-scale targeted government intervention in the innovation system and support to knowledge-based firms, technologies, products and services are required to make up for declining innovation support from the private sector and boost economic growth. “Picking winners” approaches that proved successful during World War II and the post-war period need to be pragmatically revisited, beyond ideological strictures, to speed up recovery from the current economic crisis and manage the transition from an industrial to a knowledge-based regime.

Introduction

The causes of the economic crisis that emerged in 2007-2008 have been subject to a wide international debate. Triggered by the collapse of the real estate market as a result of reckless and unsustainable lending practices in the United States, and facilitated by the failure of regulators and supervisors in spotting and correcting the emerging weaknesses, the crisis spread fast to the global financial system and then into the world economy. Comparisons with previous crises have been often made, arguing that the current slump is likely to be unusually long, more severe and slower to recover than the Great Depression of the 1930s, due to the global integration of markets that synchronized the recession (IMF, 2009).

Such comparisons, however, fail to acknowledge a fundamental difference from other crises: the fact that it occurred in the transition from an industrial to a knowledge-based society and is thus potentially subject to a different set of dynamics than those manifested for instance in the Great Depression, which occurred within an existing mode of production. An industrial mode of production has now run out of steam in many countries, making more urgent to foster the generation of knowledge-based growth firms, products, technologies, services and an innovation culture altogether. Therefore, a qualitatively different response is needed to address the current downturn – one that ensures that the recovery is durable and sustainable, and does not damage the drivers of long-term growth, but rather uses them as a springboard

to accelerate structural shifts towards a stronger economic future.

In contrast to the 1930's when Keynesian measures to stimulate use of existing productive capacities might have sufficed to end depression, the current downturn requires new productive capacities. Beyond putting people to work as an end in itself, we now face the need to create new forms of work to make up for job loss in shrinking industries. Policy-makers faced with the continuing dilemma of putting resources into saving the old or building the new should simultaneously pursue a dual strategy, balancing Keynesian stimulation of the old economy and infusing salvageable old firms with new technologies and advanced research and technology to create new industries.

We argue that a "Picking Winners" approach that has long been criticized for ineffective government intervention in the economy should be pragmatically revisited beyond ideological strictures. It may prove useful in re-assessing the mechanisms, policies and strategies that government could employ to speed up recovery from the economic crisis and assist transition from an industrial to a knowledge-based mode of production during a downturn.

We start by providing a brief account of the evolution of the "Picking Winners" concept over the last three decades or so, emphasizing the shift from the strong ideological opposition of the 1980s to the more flexible approaches adopted by many countries in recent years as a result of largely disappointing results in implementing free-market reform packages in various parts of the world, such as Latin America or the transition countries of Central and Eastern Europe. We continue with an analysis of the rationale for government intervention in the economy, contrasting neo-classical, Keynesian, evolutionary economics and the Triple Helix model, and assessing their capacity to respond to the challenges of the current crisis. Next, we provide four examples of large-scale government support to innovation and technological development in the United States, which show not only that a well-thought "Picking Winners" approach may be beneficial to fostering innovation and long-term growth, but also illustrate the importance of joint action of government, industry and university actors in this process. We conclude with a set of general principles for "Picking winners" which can be further examined in specific national and regional economic and political contexts and serve as the basis for a new range of government policies to foster innovation and economic recovery.

1. The rise and fall of free-market fundamentalism

The "Picking Winners" concept has long been used in a negative context associated with ineffective government intervention in industrial policy. One possible reason is the perpetuation of "...an ideology that says government intervention is always bad and leaving the private sector to its own devices is always good... despite... its failure...in practice" (Krugman, 2009). Another is the need to limit and regulate government intervention in the economy for fear of breaking competition rules. Yet another is that many scientists, fearing loss of research funds, argue that the existing breadth of scientific expertise provides a present and future competitive advantage that would be lost by investing in only a few potentially new and innovative developments (Cobyryn, 2009).

The controversy surrounding the term was present already in the 1980s, during the Thatcher/Reagan era. Although the two leaders promoted largely similar liberal and laissez-faire policies, there often were important differences of vision between them. Reagan's

supply-side economics (also known as “Reaganomics”) aimed to stimulate the economy through reduced business regulation, controlling inflation, reducing growth in government spending and large tax cuts, had both a positive effect, with improvements in certain key economic indicators, and a negative one, with large increases in federal budget deficits and the national debt. Reagan’s close political ally, Thatcher promoted a philosophy based on deregulation, particularly of the financial sector, flexible labour markets, and the selling off of state-owned companies. However, Reagan did not share Thatcher’s ideological consistency in rejecting intervention, but pragmatically put ideology aside to further pressing national interest.

The implications of these different visions were far-reaching. For example, Lord Sainsbury recently asserted that the UK missed its opportunity to develop a viable semi-conductor industry when Thatcher turned down a proposal to support further development of innovations made by the Ferranti firm that were beyond the company’s ability to take forward without governmental assistance, and the field devolved into a marginal enterprise in the UK, while the Republic of Korea successfully developed a semi-conductor industry (Sainsbury, 2009). In contrast, when the leaders of the US semi-conductor industry asked government support to establish a consortium to develop new production machinery to leap frog Japanese advances, President Reagan, despite his rhetoric, gave the go-ahead for the Defense Department to support the project jointly with industry. SEMATECH, a joint industry-government programme, was thus created to develop collaborations like the Centre for Integrated Systems at Stanford that brought researchers from firms across the industry together with academics to work on joint projects. SEMATECH successfully moved the US semiconductor industry to a new generation of technology and, once the industry was profitable again, continued without further government support. Industry leaders have recognized that government support was indispensable to their revival, but the strength of anti-government ideology has been so strong that there has been little public recognition of government’s role.

The strong belief in the expanding role of the free market and reduced government intervention was largely affected in the 1990s, after the mixed success of neoliberal reform policies generally associated to the so-called “Washington Consensus” that emerged in the early 1990s as a reaction to the macroeconomic crisis that hit much of Latin America and some other developing regions during the 1980s (Williamson, 1989). In spite of some longer term improvements in economic performance in a number of countries that adopted relevant policy changes (e.g. Chile, El Salvador, Uruguay and Brazil), the Washington Consensus is generally thought to have failed to provide significant overall results on growth, employment and poverty reduction in many countries, e.g. the transition economies of Central and Eastern Europe.

Much of this limited impact was attributed to its lack of emphasis on mechanisms for avoiding economic crises and application in reforms that were incomplete and insufficiently targeting improvements in income distribution (Williamson, 2002). Although a “second generation” of reforms and policies addressing inequality and social issues was subsequently proposed (e.g. Birdsall and de la Torre, 2003; de Ferranti and Ody, 2006), the Washington Consensus has lost much of its influence and new mechanisms to boost economic growth are fervently sought: *“While the lessons drawn by proponents and skeptics differ, it is fair to say that nobody really believes in the Washington Consensus anymore. The question now is not whether the Washington Consensus is dead or alive; it is what will replace it”* (Rodrik, 2006).

Indeed, various government-supported national initiatives aimed to recognize and exploit opportunities for economic growth emerged in the 1990s, such as the UK Technology Foresight Programme (Georghiou, 1996), exemplifying a declining pressure on welfare societies to conform to *laissez-faire* dictates, as well as some of the constraints on government intervention. In late 2003, a renewed focus on “industrial champions” has emerged in Europe, in the context of concerns about deindustrialization repeatedly expressed by various Member States and the European Council, but also following the commercial and industrial successes of Airbus coupled with Europe’s weak performance in other high-technology sectors. France’s new Agency for Innovation, established in 2005, that allocated over EUR 80 million to big innovation projects in biotechnology and pharmaceuticals, medical technologies, agro-food and environment technologies is a good example of new forms of government direct support to innovation and economic growth. The French bail-out of Alstom, the E.ON-Ruhrgas saga in Germany, the Franco-German-Spanish calls to create a European “champion” in shipbuilding and the trade conflict with the US on subsidies to Airbus and Boeing, are also examples of the drive to protect or support industrial champions (Maincent and Navarro, 2006).

More recently, since the end of 2007, the large-scale government interventions generated in response to the current economic crisis with the aim to forestall depression as well as rescue the financial system, have revealed fundamental flaws in the market self-regulation myth, shaken confidence in the virtues of lightly regulated markets and free capital movements, and opened the way to a less ideologically charged debate about the role of the state in development (Wade, 2009).

After rescue plans to avoid a collapse of the financial and banking systems and limit the economic effects of the credit crunch, economic stimulus packages meant to revive economic growth became the most common policy tool in many countries, including the US, the European Union, China, India, Japan, Australia, Argentina, etc. In addition to political responses provided by individual nations, a globally coordinated response, including proposals on international financial regulation, economic support and anti-protectionism measures, was considered at the November 2008 summit of the G-20 group of major economies. Also, the OECD is developing a strategic response to the crisis focusing on two priority areas: finance, competition and governance; and restoring long-term growth.

Moving away from the ideological opposition of the last decades, a “picking winners” approach, especially in innovation and technological development, could prove useful to recover from the current economic crisis. It has now become clear for many governments that, rather than attempting to restore economic growth by adopting expansionary fiscal and monetary policies, inflation strategies, cuts on health insurance and retirement pension benefits, downsizing or even using bankruptcy as a way to drastically cut wages and benefits, **the ability to scale-up innovation initiatives in selected areas is essential for long-term economic growth.**

The need for targeted government intervention in innovation and technology development is all the more needed as these areas have been hit hard by the economic crisis: research and development spending has declined in many countries, US venture capital investments plunged 60 percent in the first quarter of 2009, similarly to Europe and in China, patent applications have gone down and incentives to develop a greener economy have been weakened by the crisis (OECD, 2009)

The necessity to foster innovation, entrepreneurship, investment in research and development goes hand in hand with the need for education and labour policies to upgrade workers' skills, provide adequate numbers of workforce and ensure stable employment. Layoffs are announced at worrying pace almost daily in high-tech industries, like IT, aeronautics or pharmaceuticals, and knowledge-intensive services like financial services, and this human capital is likely to will quickly depreciate if the downturn is protracted. Industrial firms are shrinking, and even if they recover with the help of an infusion of new technology, their employment bases will be smaller. A crisis of Biblical proportions - a seven-year downturn - may be at hand if effective action is not taken to foster employment growth (Herbert, 2009). To renew employment and stimulate demand, government action has to extend beyond saving existing industries into creating new industries that rely more heavily on a knowledge base.

The task is by no means easy. A downturn creates pressure for even a *laissez-faire* government to rescue old industry, while the support for creating the new may be weak or even missing, potentially reducing the government funds that may be available for innovation and entrepreneurship. The "innovation contradiction" is that it is in the downturn, when human resources are most available and when firm formation is especially needed to generate new jobs, that private sector resources to support entrepreneurial activity are least available. "Creative destruction" is all too apparent during a downturn, but its positive side, "creative reconstruction" may be less evident because it is policy-driven rather than market-driven. Government leadership is required to make the case for building the new economy through countercyclical measures (going against the business cycle) to provide funds through public venture capital.

The practical, concrete ways to achieve "creative reconstruction" need to be defined, in a collaborative, synergic manner that goes beyond traditional institutional boundaries. Large-scale targeted government intervention in the innovation system, balancing long- and shorter-term policy measures requires strategic options at the level of both governments and societies as a whole. Public support is essential to cross the ideological divide from *laissez-faire* to active government. To bridge this gap, public understanding needs to be sustained that we are at the cusp of transition from an industrial to a knowledge-based society, requiring policy initiatives to cross the Rubicon. Churchill provided the leadership that scaled up British preparation for the onslaught of the Second World War through speeches that catalyzed public support. Roosevelt similarly gained support for far-reaching measures to address the depression through his "fireside chat" radio addresses. Having faced the crisis of economic transition in the early 1990's, Finland's political leadership responded by focusing attention on innovation issues and raised them to the highest level of national priority. Technical, political and financial resources have been mobilized to create new knowledge-based industries for almost two decades, providing a policy model for other countries to emulate (Peltonen, 2009).

2. Grounds for government action: from neo-classical economics, Keynesianism and evolutionary economics to the Triple Helix model

While the role of the government in restoring economic growth has become a subject of little dispute in the context of the economic crisis, the key areas and mechanisms of intervention remain at the centre of a heated debate. Economic stimulus packages in various countries around the world have been an unproven success so far. Uncertainty over the adequacy and effectiveness of the proposed measures has determined some countries' reluctance to spend

more money addressing the crisis. “The switch from decades of supply-side politics all the way to a crass Keynesianism is breathtaking” declared the German Finance Minister Peer Steinbrück in early December 2008, arguing that “A Great Rescue Plan...doesn't exist. Dealing with an unprecedented crisis is a puzzle, a trial-and-error” (Newsweek, 2008). In a similar vein, the EU presidency warned the European Parliament in March 2009 that the US and UK economic recovery plans are “a way to hell” (Telegraph, 2009).

Keynesianism and neo-classical economics have been so widely embraced as they appeared to be the best-known schools of thought that offered a justification for and an example of government intervention in the economy.

Neo-classical economics provides a specific criterion for government action - the existence of a “market failure”, i.e. when the production or use of goods and services by the market is not efficient, or an activity cannot or will not be taken up by the private sector, but there is a public good to be attained, especially one that will advance the productivity of industry. In this case, it is allowable, possibly even incumbent upon government to act. Nevertheless, some types of government policy interventions aimed to correct market failure, such as taxes, subsidies, bailouts, wage and price controls, may also lead to an inefficient allocation of resources, sometimes called “government failure”, which complicates the choice between imperfect market outcomes and government interventions.

Keynesianism advocates a mixed economy - predominantly private sector, but with a large pro-active role of government and public sector in exploiting un-used industrial capacity to stabilize the business cycle. Keynes' ideas for government to revive the productive capacities of the industrial society were intermittently adopted during the Great Depression of the 1930s, and later served as the ideological base to recover from World War II and manage the economic growth of the post-war Golden Age of Capitalism (1945–1970). Even before that, he prematurely noted the end of the *laissez-faire* regime, expecting acceptance of a significant role for government in the economy (Keynes, 1926). For example, public infrastructure, social and cultural capitals were enhanced through various conservation, economic development and employment programmes (Rose, 2009). Young people undertook reforestation projects under army supervision in the Civilian Conservation Corps (CCC). The Works Progress Administration (WPA) employed millions of persons in virtually every locale on projects large and small, building everything from roads and bridges to schools enlivened by artist's murals. The WPA also sponsored theatre groups and hired writers to produce guidebooks to each state. The Public Works Administration (PWA) undertook larger scale projects such as dams to produce power, reduce flooding and irrigate farmland. The Rural Electrification Administration (REA) lit farms, reducing isolation and social disparity. It also hired photographers to document gritty perseverance in the face of economic and social adversity. However, as programmes to create employment had an effect, they were often scaled back due to ideological opposition. The Roosevelt administration's response to the Great Depression was large scale, yet intermittent. The success of Keynesian measures by 1937 led the Administration to conclude that government should relax, rather than redouble its efforts to revive the economy, causing an unnecessary downturn (Romer, 1991).

Evolutionary economics is vague, offering no specific criteria for government intervention, just a theoretical context for a broad institutional framework for the development of markets. In particular, the so-called “evolutionary targeting” provides a dynamic policy perspective focused on triggering, re-enforcing and sustaining market-led evolutionary processes of emergence of Multi-agent Structures (industries, clusters, markets, etc.) through discrete

policy interventions in varying areas of system/market failure that appear at different phases of the overall process (Avnimelech and Teubal, 2008; Barber, 2009). Government is one element of this framework that may engage in trial-and-error efforts to improve the innovation process and induce learning.

Both neo-classical and evolutionary approaches expect innovation to be a firm-based process that takes into account incremental change, but not the effects of a large-scale economic crisis, requiring discontinuous innovation.

The Triple Helix model of university-industry-government interactions goes beyond the firm- and market boundaries, emphasizing knowledge-based linkages between innovation actors that are much more relevant in addressing the current economic crisis, as it takes place in the transition from an industrial to a knowledge-based society, rather than within a single mode of production. Industry as a single helix strategy was inadequate to transcend the 1930's depression - industry by itself was a sub-optimal economic actor. A double helix of industry-government as primary institutions of the industrial society was the great transformation of the 19th century (Polanyi, 1944)¹, but in the 20th century it proved insufficient to bridge the transition between industrial and knowledge-based modes of production. A triple helix of university-industry-government as the key stakeholders of the Knowledge Society emerged, first at the national level during World War II to promote development of scientific weapons increasingly, and later at the regional and local level in support of knowledge-based economic growth. After World War II, some scientists learned the lesson that their ability to translate technical knowledge into weapons and other useful devices not only gave them access to government officials, but admitted them into decision-making circles as well. In subsequent decades, scientists enacted a variety of insider and outsider political roles, from controlling the consequences of atomic weapons to highlighting the economic potential of scientific research in the debate over reindustrialization during the downturn of the 1970's.

Conflicts arising from new modes of production were solved by adopting new legal frameworks that not only allowed conflict resolution, but also provided a framework for knowledge-based innovation. For example, the U.S. Bayh-Dole Act of 1980, giving universities an economic role by granting them control of intellectual property rights from federally-funded research with the mandate to promote commercialization, was a landmark event and was replicated, in more or less similar forms, in many other countries. More recent examples include US open industrial policy initiatives, such as the virtual nationalization of the greater part of the automotive industry, in contrast to previous indirect and hidden measures (Etzkowitz, 1994). In Sweden, a third mission was introduced to encourage universities to foster technology transfer and firm formation. The VINNOVA agency was established, drawing together elements of previous agencies focused on supporting particular industrial and technology sectors, playing a broad role through its education and grant programmes, incentivizing regional Triple Helix coalitions to coalesce and developing projects to revive existing industries and foster new ones (Benner and Sandstrom, 2007).

3. "Picking Winners": Learning from the Past

In the run-up to World War II, the British Air Ministry issued specification F.7/30, with

¹ On the one hand, the market became the organizing principle of social relations while, on the other, the Speenhamland Law of 1795 placed limits on exchange relationships and guaranteed workers a living wage.

general design criteria for a high-speed fighter aircraft capable of mounting a battery of machine guns. The field was open to design innovations since F.7/30 did not specify how to reach these objectives. Limited resources had to be focused, so a few candidates was a reasonable choice. The Ministry selected two firms' proposals to back: the Hawker Hurricane and the Supermarine Spitfire. In the end, it was the Spitfire, the "long shot" presented by a marginal firm, previously known for racing success with its seaplanes, which emerged as the clear winner. If the well-known firm had been given all the resources, the ultimate winner would have been discarded. Indeed, the Spitfire aircraft has been widely credited with providing the technological edge that won the Battle of Britain (Bishop, 2003).

This example illustrates a leading role for government in technological innovation that was well accepted in wartime *laissez-faire* societies. Many other innovations, including radar, the proximity fuse and penicillin were brought to fruition during the war with government playing, if not always a first mover role as with F.7/30 a significant and indispensable role, typically in partnership with leading scientists who were brought into government both as scientific advisors and as S&T agency administrators. Government actions thus took place at the intersection of the state and the scientific community, through hybrid organizations in the US, like the Office of Scientific Research and Development (OSRD) and through scientific advisors, with the ear of Churchill and Roosevelt. Significant resources were put at the disposal of scientists who had considerable say on which technological innovations to back in contrast to World War I in the US, when scientists were largely limited to following the prescriptions of the military. The key difference was that the military largely worked within existing technological paradigms, frustrating the scientists who often wished to move "outside of the box."

Once *laissez-faire* strictures are removed, several models of government intervention in innovation are available to address the economic crisis. We discuss here four successful US initiatives in picking technology winners spanning the period from World War II to the present:

- The Office of Scientific Research and Development (OSRD);
- The Defense Advanced Research Projects Agency (DARPA);
- The Small Business Innovation Research Programme (SBIR) and
- The Advanced Technology Programme (ATP).

The first three may be viewed in chronological order as representing a descending order of scale and scope, from an integrated innovation regime, moving from problem to solution and from idea to production, to one that addresses only the upstream stages. OSRD shows importance of adequate scale of resources to address the problem, while ATP shows the consequences of inadequate resources and the importance of placing academic centres at the heart of industrial consortia to achieve continuity and commitment. ATP largely failed due to a mismatch between the scale of the problem selected, typically large, and the resources it could bring to bear, usually small. SBIR reduced the "Valley of Death" by funding upstream translational research, but there was often still a gap further downstream, sometimes addressed by state government programmes and sometimes not, leaving some significant projects to wither and fall by the wayside. DARPA suggests the importance of creative leadership. SBIR provides a model to bridge the early stages of commercialization, especially in a downturn, when private venture capital dries up, necessitating a countercyclical public substitute to stimulate the innovation process. All examples also show the importance of focusing relevant technical resources on a clear goal, once an objective is set, whether at a common site or through decentralized collaboration.

In addition, the four examples discussed below not only suggest the viability of a “picking winners” approach to discontinuous technology development, with a strong role for government, but also illustrate Triple Helix collaborations of university-industry-government that might be more relevant nowadays in addressing the current economic crisis than Keynesian, neo-classical or evolutionary economics. Even in the ATP case, an explicit bi-lateral government-industry programme with academics excluded from leadership roles, in its actual operation, some of the most successful projects in the healthcare information initiative involved universities as sub-contractors who played a more significant initiatory and operational role than indicated by their subordinate status in the project (Etzkowitz and Spivack, 2001). Universities provided a neutral ground for centres to carry out the SEMATEC project, bringing company researchers together at federal government-subsidized facilities on campus, reprising some of the wartime OSRD model. Similarly the policy entrepreneurs at NSF and DARPA incentivized university researchers to participate in joint university-industry government R&D projects, promoted circulation around the Triple Helix spheres and collaboration among them. By providing a research-based format to commercialize academic research, SBIR created a seamless web between university-industry and government to move incipient technologies towards the marketplace.

The Office of Scientific Research and Development (OSRD)

In the run-up to World War II, an elite group of academic and industrial scientists pondered how they could best use their skills and the potential of science to advance the nation’s cause in the expected war. They took the leading role in creating OSRD, recruiting the heads of leading industrial labs as their junior partners before proposing an organizational plan that was accepted by government at the highest level, President Roosevelt and his key advisors, with whom the academics built a working relationship from the base of the Carnegie Institution of Washington, a research institute which became their representation arm in the Capitol. Initially recognized as a government-sponsored committee and then as an agency independent of the military, the OSRD had the remit to address problems posed by the military, but also originate significant projects on its own, going from fundamental science to final production and testing (Stewart, 1948; Baxter, 1996). There was a balance between autonomy and direction with loose coupling between a stated goal and the means for reaching that objective. Research was carried out through contracts with universities to establish labs rather than in government labs at their own sites. Recruiting a leader who was a key node in a technical network with ability to recruit the best available researchers was key to success of a lab (Leslie, 1993). Frederick Terman, who was called to Harvard from Stanford Engineering School to head the Radar Countermeasures Lab, exemplified the academic with a broad range of university-industry contacts, who was able to move from mentoring a relatively few students successively in peacetime to directing a large-scale wartime Lab.

Thousands of university researchers were recruited from around the country to MIT’s so-called “Rad Lab” for the development of radar. Innovation was pursued from all angles simultaneously: forward linear from scientific ideas, reverse linear from military needs, projects that combined research with small-scale production in the lab. Boundary-spanning innovation formats, integrating research and production, were invented to collapse time frames. These resource-rich, time-limited R&D projects sent scientists into the field to identify problems in test models and brought manufacturing experts into the lab from firms to start preparing manufacturing designs to make experimental devices ready for production runs before R&D was completed. Innovation gaps that plagued government-supported research in the post-war and were only partially resolved over the decades, were

expeditiously solved in the “anything goes” atmosphere of wartime where university-industry and government worked in harness.

Although Vannevar Bush, its Director, immediately disbanded OSRD at the conclusion of hostilities, he had earlier arranged for President Roosevelt to request a proposal for a government role in peacetime research. The result was *Science: The Endless Frontier*, a volume whose title became a widely accepted metaphor for “blue sky” research (Bush, 1945). The specific chapters of the report, prepared by committees of academics, industrialists and government officials on health, transportation, housing, military research, etc. are seldom referred to (Stokes, 1997). One element of the report—fundamental research— led to the National Science Foundation (NSF), a pared down version of the much broader agency that Bush envisioned (Hart, 1998).

OSRD exemplifies a mechanism of a scientist-led research agency through which the government introduced and supported discontinuous innovation into military conflict during World War II. It also illustrates a full-scale model of a university-industry-government concerted approach to technological advance and economic development that was invented at the advent of World War II. Wars were previously fought with weapons available at the inception of the conflict, the objective being to produce large quantities and achieve incremental improvements along the way. World War II led to the scale-up of research models and transformed academic research, at least in physics and engineering, from an individualistic to a group phenomenon and from a parsimonious endeavor to a well-funded enterprise. Once the apple of government largesse had been bitten, few wished to return to a scarcity regime.

The Defense Advanced Research Projects Agency (DARPA)

DARPA was created in response to the “Sputnik shock” of 1957 when the Soviet Union surprised the US by launching a satellite first. This was broadly interpreted as implying not only Soviet leadership in the space race, but more broadly in science and technology in general. Statistics on graduation rates of engineers in the two countries were cited to further deepen the gap. The response thus included new graduate fellowship programmes, a Cabinet Level advisor to the President on Science and Technology (S&T) and DARPA, an agency with the mission to advance emerging areas of S&T that had broader relevance than any single mission oriented agency might foresee.

DARPA was given the authority to do whatever was necessary, from funding basic research to provision of venture capital to achieve its goals. The DARPA programme officer, a public entrepreneur, is the key to the DARPA model, which is for a programme officer in temporary government employ, typically seconded from academia or industry, to design an innovation programme bringing together relevant university researchers and firms to accomplish a far-reaching objective. All phases of the research and innovation process may be supported over a relatively long time period. Harvard psychologist J.C.R. Licklider, who envisioned a new format for computer communication that led to the Internet, exemplifies these highly-skilled, broad-gauge technologists and visionaries, often drawn from universities. Following the DARPA format, Licklider had the freedom and the resources to fashion a consortium from across university, industry and government laboratories to realize his vision of fault tolerant computer mediated communication networks (Haffner, 1998).

Although DARPA is required by law to achieve military goals, many of its initiatives, like the Internet, have had significant spillover into the civilian economy. A data mining initiative

provided the framework and resources for the invention of the Google algorithm. Nevertheless, discussions of the origins of Google typically begin with the meeting of two like-minded graduate students, ignoring the substrate of government goal-oriented research support that underpins much of graduate training in computer science at Stanford and other leading universities. There have been various proposals for a civilian DARPA, but the political will has been lacking until quite recently. Only military objectives have been granted an exemption from the dictum of government's supposed inability to pick winners.

The Obama Administration has recently established an Energy ARPA. However, at least in its first iteration, it is said to be functioning according to a National Science Foundation individual investigator led model, more appropriate to basic research in accepting a broad range of research proposals and exercising little strategic direction (Science, 2009). This "over the transom" approach was perhaps necessitated by time –urgency and an initial small staff, and perhaps even lack of awareness of how the DARPA model, that it is presumed to be following, actually works. On the other hand, the Obama Administration's Energy leadership has exercised strategic direction in pulling back from the very long-term "hydrogen economy" models favored by the Bush Administration, but has not yet set a clear priority or two. Perhaps an F.7/30 like specification is in order and/or recruitment of Licklider-like individuals with a technological vision.

The Small Business Innovation Research Programme (SBIR)²

In recent decades, despite being limited by *laissez-faire* ideology to provide basic research capabilities that industry is unwilling to support, government has played an innovative role in supporting new high-tech firms through the Small Business Innovation Research Programme (SBIR). Begun by programme officers at the NSF in the early 1980's, its founders hid their industrial policy intentions by extending the NSF's basic research funding model, relying on technology experts, often from the private sector, to judge commercial potential even as it typically relies on academics to certify scientific and technical merit (Gulbrandsen and Etzkowitz, 1999). After demonstrating success, SBIR was extended from NSF to all government agencies with research budgets of more than \$100 million.

Researchers often use SBIR grants as the first step toward firm-formation, without needing to actually form a firm in advance of receiving a grant. The "basic research" format of SBIR has had the unintended consequence of supporting early stage ideas with commercial potential, in contrast to programmes that may require a firm to support 50% of a project, typically limiting the selection to close to the market ideas. Programme officers set topics, extending from their remit into areas of potential industrial interest, often through informal consultation with users. SBIR fills some of the gap, the so-called "Valley of Death" that business angels and private venture capital firms are typically unwilling to enter until a firm has demonstrated earnings (Wessner, 2008). Thus, public and private venture capitals are complementary, with government playing the role of seeding the private venture capital industry (Wessner, 1999).

The Advanced Technology Programme (ATP)³

ATP was initiated during the Bush senior administration in response to concerns that US multinationals would move R&D to Europe to take advantage of European Union Framework

² This section draws upon Etzkowitz, Gulbrandsen and Levitt (2000), *Public Venture Capital* New York: Harcourt)

³ The ATP discussion is primarily based on interviews conducted in 1996 by the first author as part of an evaluation of the Information Infrastructure in Health Care ATP Initiative.

Programme support. ATP granted most of its funds to consortia of large firms, sometimes supplemented by university researchers. ATP projects often received only intermittent attention by their industrial partners. Even though some ATP projects, such as its automotive initiative, were in the tens of millions, this was an insignificant sum for firms that spend many orders of magnitude beyond that on a new model. If an initial champion was transferred or firm direction changed, the relatively small ATP initiative might fall by the wayside.

However, the scale of funding, even if insignificant to large firms, was sufficient to catch and hold the attention of academic partners who moved the projects forward. Indeed, university researchers sometimes initiated projects by recruiting industry partners to take the official lead, through a Trojan Horse stratagem of university entrepreneurs finding firms to front their proposals. Indeed ATP programme officers were often the instigators of consortia, surreptitiously talking the more pro-active role of DARPA programme managers in order to drum up sufficient interest among firms to apply. Political opposition to the ATP reduced its funding and led to a shift towards grants in the low millions for innovative start-ups, turning ATP into a useful follow-on to the SBIR. ATP is currently emerging out “deep freeze” in the National Institute of Science and Technology, its sponsoring agency, as the Technology Investment Programme (TIP), after having received no new funds in recent years.

4. Intervention mechanisms and policy implications

A key question emerges from the four examples of successful government support to specific industry sectors or technologies described above: how can they be replicated in the current economic context, moving beyond the ideological opposition that accompanied the concept over the last decades?

A set of general principles for “Picking Winners” may be derived from the discussion above, which need to be further examined in specific national and regional economic and political contexts:

- **Accurately assess the scale and scope of the crisis in order to formulate a commensurate response.** In a downturn, there is a natural tendency to focus on retaining old areas of the economy for fear of worse to come, but the slowing economic shrinkage does not address the more fundamental issue of creating a future economy, more tied to technological than financial innovation. The creation of a civilian-oriented OSRD and DARPA, and an expanded SBIR may speed up the post-war model of stimulating the science base, supplemented by relatively modest efforts to assist the linear model and translate research results into use.
- **Define clear objectives and aggregate sufficient resources to achieve them.** Aggregating adequate resources becomes ever more difficult as the potential resource base decreases in size, as typically is the case in small countries. The problem is further exacerbated when there are strong pressures to simultaneously pursue a broad range of alternatives (e.g. the Netherlands, see Hekkert, 2009). Moreover, existing technologies are protected by strong lock-in mechanisms and subsidies, both direct and indirect (Etzkowitz, 1984). Even when R&D resources are made available in the early stages of innovation, government funding is rarely available on the scale necessary to bridge gaps in the later, more expensive, stages of the innovation process (Hekkert, 2009). If large countries, such as the US, may aggregate significant human and material resources for technology development, smaller countries need to act together to achieve the critical mass to match the scale and scope of the effort needed to bring a significant new

technology on line that has heretofore largely been restricted to large countries. In this context, cross-national collaboration to aggregate sufficient resources is indicated to achieve a breakthrough that a single country may be unable to achieve⁴. In addition, increasing the integration of financial markets and improving access to finance is an important condition for the survival and sustained growth of start-ups and small and medium-sized enterprises, particularly in high-tech sectors. Counter-cyclical public venture capital is required to break the "iron discipline" of the business cycle.

- **Carefully consider the strengths and weaknesses of the national, regional and local industrial structure** (large companies vs. SMEs, activity in traditional low- and medium-tech industries vs. new high-tech ones, the number and potential of international vs. domestic players, etc), and its sectoral specialisation. A correct assessment of industrial characteristics is essential for successful support. The risk of making the wrong choices is much higher for a domestic industry at the technological frontier or in sectors fraught with technological and market uncertainties, while supporting a domestic industry catch-up towards a foreign technological leader can be a safer option. Nevertheless, advances in most high-technology industries such as biotech, nanotech or medical devices imply assuming high risks, as the nature and pace of technological progress in these areas is different than in low- and medium-tech industries (Maincent and Navarro, 2006)
- **Design a selection process with clear criteria and time-frame** to insure that the technical choices are feasible and capable of scale-up within a reasonable period.
- **Incentivize university-industry-government collaborations**, so that a balanced approach may be taken without government having to be the sole actor.

A number of OECD countries have already adopted important innovation and entrepreneurship support measures in their economic stimulus packages, next to other measures such as improving the infrastructure (e.g. roads, mass transit, ICT), investment in human capital, education/training, including schools, teachers, promoting the investment in and uptake of green technologies and innovations to foster energy-efficiency and sustainable economic growth. In terms of financial weight in stimulus packages, infrastructure investments, education and sometimes green technologies are the first and second most important of these spending items, although in many cases these components are related, e.g. infrastructure overlaps with spending on R&D (new laboratories) and spending in education category (new schools) (OECD, 2009).

The effects of such policies may necessitate a longer time to observe. In the past, it often took considerable time to renew a failing economic base. For example, a half century intervened from the beginnings of the economic decline of New England in the early 20th century to its post-war revival, based on the invention of venture capital and the founding of the minicomputer industry. To address the current crisis, we must, like Moses, look over the horizon, to the promised land of the Knowledge Age, and be aware that the forces of "creative destruction" identified by Joseph Schumpeter (1942) work at an ever more furious pace during a downturn. Expressions of concern over growing national debt may be answered

⁴ An example of such multi-country collaboration is the Six Country Programmeme of the Innovation Policy Network, which is an international network of public policy-makers, business leaders, academics, and other experts working in innovation (see <http://www.6CP.net>). The members meet periodically to discuss the latest developments in innovation research, policy and practice. Established in 1975, the 6CP provides a platform for open discussion and analysis of innovation policy issues and exchanges of experiences and best practices in the field. The movement to a European Research Area has also encouraged many other EU initiatives to establish a model of aggregating resources to undertake larger collaborative projects.

by reference to the new productive forces, and future tax revenues created by investment in new technologies. If we develop a far-reaching plan and take effective action we may not be consigned to wander aimlessly for fifty years.

References

- Avnimelech, G. and Teubal, M. (2008). Evolutionary targeting. *Journal of Evolutionary Economics* 18 (2): 151-166.
- Barber, J. 2009. 'Setting the Scene'. 6 Country Programme Workshop: New Economic Ground for Innovation Policy. Bilbao 13-14 September
- Baxter, J. 1996. *Scientists against Time*. Cambridge: MIT Press.
- Benner, M and U. Sandstrom. 2007. "Shaping Strategic Research: power, resources and interests in Swedish Research policy". *Minerva* 45 (1): 1573-1871.
- Birdsall, N. and A. de la Torre. 2001. *Washington Contentious: Economic Policies for Social Equity in Latin America*. Washington: Carnegie Endowment for International Peace and Inter-American Dialogue.
- Bishop, P. 2003. *Fighter Boys: Saving Britain, 1940*. London: Harper Collins.
- Bush, V. 1945. *Science: the Endless Frontier*. Washington DC: US Government Printing Office.
- Corbyn, Z. 2009. 'Academics warn against policy of 'picking winners' to fund'. *Times Higher Education Supplement*. 12 February.
- Etzkowitz, H. 1984. Solar Versus Nuclear Energy: Autonomous or Dependent Technology? *Social Problems* 31 (4): 417-434.
- Etzkowitz, H. 1994. Technology Centres and Industrial Policy: the emergence of the interventionist state in the USA. *Science and Public Policy* 21 (2): 79-87.
- Etzkowitz, H. 2008. *The Triple Helix: University-Industry-Government Innovation in Action*. London: Routledge.
- Etzkowitz, H. and R. Spivack. 2001. Information Infrastructure for Healthcare: An Evaluation of a Government-Industry Technology Development Initiative *Technology Analysis and Strategic Management*, 13 (4): 507-521.
- De Ferranti, D. and A. J Ody. 2006. Key Economic and Social Challenges for Latin America: Perspectives from Recent Studies. Available at: <http://www.cfr.org/publication/11418/brookings.html>
- Gulbrandsen, M. and H. Etzkowitz, 1999. Industrial Policy in Europe and America. *Journal of Technology Transfer*. 24 (2/3): 223-233

- Haffner, K. 1998. *Where Wizards Stay Up Late: The Origins of the Internet*. New York: Simon and Schuster.
- Hart, D. 1998. *Forged Consensus: Science, Technology and Economic Policy in the United States, 1921-1953*. Princeton: Princeton University Press.
- Hekkert, M. 2009. The Challenge of Sustainable Innovation Policy. 6CP Workshop: New Economic Ground for Innovation Policy. Bilbao 13-14 September.
- Herbert, B. 2009. "No Recovery in Sight" *New York Times* 27 June.
- IMF. 2009. 'IMF warns over parallels to Great Depression'. *Telegraph*, 16 April 2009. Available at: <http://www.telegraph.co.uk/finance/financetopics/recession/5166956/IMF-warns-over-parallels-to-Great-Depression.html>.
- Keynes, J.M. 1926. *The End of Laissez-Faire*. London: Hogarth Press.
- Krugman, P. 2009. All the President's Zombies. *The New York Times* 24 August.
- Leslie, S. 1993. *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford*. New York: Columbia University Press
- Main, Paul. 2009. "Personal Communication" January 15.
- Maincent, E. and L. Navarro. 2006. *A Policy for Industrial Champions: From picking winners to fostering excellence and the growth of firms*. Industrial Policy and Economic Reforms Papers No. 2. Enterprise and Industry Directorate-General, European Commission.
- Newsweek. 2008. 'It Doesn't Exist!', *Newsweek*, 6 December 2008. Available at: <http://www.newsweek.com/id/172613>.
- OECD. 2009. *Policy Responses to the Economic Crises: Investing in Innovation for Long-term growth*. Available at: <http://www.oecd.org/dataoecd/59/45/42983414.pdf>
- Peltonen, P. 2009. The Economic Recession and Future Growth Challenge Innovation Policy. 6CP Workshop: New Economic Ground for Innovation Policy. Bilbao, 13-14 September.
- Perez, C. 2003. *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages*. Cheltenham: Edward Elgar
- Polanyi, K. 1944. *The Great Transformation*. Boston: Beacon Press.
- Shimshoni, D. 1983. "The Mobile Scientist in the American Instrument Industry" *Research Policy* (12): 1-14.
- Rodrik, D. 2006. *Goodbye Washington Consensus, Hello Washington Confusion?* Harvard University, pp. 3-5.
- Romer, C. 1991. *What Ended the Great Depression?* Cambridge: NBER Working Paper No. W3829.

Rose, N. 1993. *Put to Work: Relief Programmes in the Great Depression*. New York: Monthly Review Press.

Sainsbury, L. 2009. Keynote Speech at “The Connected University” Launch Event, 30 April. Available at <http://www.nesta.org.uk/connected-university-launch/> last viewed 09/09/09

Schumpeter, J. 1942. *Capitalism, Socialism and Democracy*. New York: Harper.

Stewart, I. 1948. *Organizing Scientific Research for War: the Administrative History of the Office for Scientific Research and Development*. Boston: Little, Brown

Stokes, D. 1997. *Pasteur’s Quadrant: Basic Science and Technological Innovation*. Washington DC: Brookings Institution Press

Telegraph. 2009. EU presidency: US and UK economic recovery plans are 'a way to hell', 25 March 2009. Available at:

<http://www.telegraph.co.uk/finance/financetopics/financialcrisis/5048291/EU-presidency-US-and-UK-economic-recovery-plans-are-a-way-to-hell.html>.

Wade, R. 2009. Rethinking Industrial Policy for Low Income Countries. *African Development Review* 21 (2): 352-366.

Wessner, C. 1999. *The Small Business Innovation Research Programme: Challenges and Opportunities*. Washington DC: National Research Council

Wessner, C. 2008. Ed. *An Assessment of the SBIR Programme*. Washington D.C.: The National Academies Press.

Williamson, J. 1989. What Washington Means by Policy Reform, in: Williamson, J. (ed.): *Latin American Readjustment: How Much has Happened*, Washington: Institute for International Economics.

Williamson J. (2002). *Did the Washington Consensus Fail?* Available at: <http://www.iie.com/publications/papers/paper.cfm?ResearchID=488>

THE OECD INNOVATION STRATEGY – TOWARDS AN AGENDA FOR POLICY ACTION ON INNOVATION¹

Note for 6CP meeting, Bilbao, 14 September 2009

Dirk Pilat, Head, Structural Policy Division, OECD, dirk.pilat@oecd.org

When Ministers in 2007 called upon the OECD to develop a strategy to strengthen innovation, increasing productivity and the potential for long-term growth and development were already pressing policy objectives. Since then, the economic context has taken a dramatic turn for the worse, with the financial crisis having spread to the real economy, bringing a steep drop in growth and millions of new unemployed. Today, as the crisis continues to unfold around the globe, the development of the OECD Innovation Strategy has taken on even greater relevance. Innovation will be one of the keys to accelerating recovery and putting countries back on a path to sustainable – and smarter – growth. Yet the crisis itself poses a number of serious risks and challenges to the innovation ecosystem. Getting the policies right is vital. Today's exceptional economic stimulus measures represent a unique opportunity for public policy to foster innovation. By providing the incentives for innovation-related investments, and accelerating activities for which barriers may have been otherwise too high, governments can help lay the foundations for a greener economy and durable growth. If this opportunity is handled effectively, countries could be reaping the benefits for decades to come.

There is an emerging view that the global economy may be at a turning point, leading to a shift in paradigm. This is indeed an era of transition. The current crisis is the latest in a series of important phenomena which continue to transform modes of production and consumption and drive the search for new and more sustainable routes to value creation. Over the past decade, globalisation and the emergence of new and diverse players have continued to accelerate, opening up new markets and opportunities, but also requiring new strategies to benefit and to stay competitive. One result has been a change in the geography of innovation, with a more complex division of labour across cities, regions and countries. Changing demographics throughout the world has also been driving the need for innovation. In OECD countries, dealing with an ageing workforce calls for new responses, be they restructuring, migration, upgrading of skills or outsourcing.

Against this backdrop of transformation, this Interim Report examines the contribution of innovation to growth, and to addressing key global challenges such as climate change, health, food security and economic development. It takes account of the new landscape and dynamics of innovation: the important linkages between traditional and new forms of innovation; its changing geography; and the challenges of governance. In examining these shifts, the report pinpoints the areas where the policy framework may need to be reassessed, or new policies and indicators developed. Specific attention is given to the foundations needed to enable innovation, including human capital, entrepreneurship, research institutions and universities, knowledge markets and infrastructure, among others. Analysis underway will result in a set of policy principles to harness innovation in the 21st century. This comprehensive strategy will be delivered to Ministers in 2010.

Innovation is a key driver of growth

Innovation – the introduction of a new or significantly improved product (good or service), process, or method – has long been viewed as central to economic performance and social welfare, and recent empirical evidence has confirmed the links between innovation and growth.

¹ This note is a slightly edited version of the Interim Report on the OECD Innovation Strategy that was presented to the OECD Ministerial meeting in June 2009, see: www.oecd.org/mcm2009

Innovation entails investment aimed at producing new knowledge and using it in various applications. It results from the interaction of a range of complementary assets which include research and development (R&D), but also software, human capital, design, marketing and new organisational structures – many of which are essential for reaping the productivity gains and efficiencies from new technologies. These “intangible” assets have become strategic factors for value creation by firms. Their role in the economy has become as important as that of tangible assets, accounting for 5 to 12% of GDP.

Better accounting of the intangible capital which drives innovation is important in furthering our understanding of the patterns and sources of economic growth. Adding it to the standard growth accounting framework changes significantly the analysis. For example, R&D expenditures and intensity have been found to have a significant effect on per capita GDP growth. And estimates for several OECD countries show that intangible investment more generally accounts for around 20 to 25% of labour productivity growth. The OECD is working with the international research and statistical community to produce a better measure of investment in innovation and its impact at the macroeconomic level.

Innovation is a “must” to meet global challenges

Just as globalisation has made the world a “smaller” place, there is an increasing realisation that many of today’s pressing challenges know no borders and cannot be tackled by a single country – global challenges require collective responses. The ability to address increasingly urgent issues such as climate change, health, food security and poverty depends on stronger innovation and new forms of international collaboration. Effective enabling mechanisms are needed, and the OECD is working to identify policies, frameworks, and governance mechanisms that can accelerate scientific and technological progress and diffuse innovation as widely as possible.

Different global challenges naturally call for different approaches to support scientific and technical co-operation. Nevertheless, some common strategies are emerging. These include greater involvement of the private sector, non-governmental and philanthropic organisations, and other stakeholders in the innovation process; building greater capacity for innovation in developing countries; devising new financing mechanisms which provide incentives for global and local innovations; and experimentation with mechanisms that enhance technology transfer to developing countries.

Climate change is one of the biggest challenges of our time, and one which can only be solved collectively. Innovation can reduce the economic costs of climate change by putting economies on growth paths that are less greenhouse gas-intensive. While this requires major progress in development and deployment of key technologies, there is evidence that innovation in climate change mitigation technologies is accelerating. Better use of existing knowledge and technologies, across sectoral boundaries, also offers important opportunities to address this and other global challenges.

A wide range of policy actions will be needed to mobilise innovation to address climate change. Setting a price for carbon emissions (whether through tradable permits or a carbon tax) and the provision of targeted R&D support for mitigation technologies by governments can be particularly effective in inciting innovation in climate change mitigation technologies. The concept of eco-innovation is being applied by several OECD governments as a way of meeting sustainable development objectives. More generally, in order to encourage innovation, it is important to provide a stable and long-term policy horizon for investors. This is particularly important for “breakthrough” technologies with a long planning horizon. And, in order to realise reductions in emissions in a cost-effective manner, developing countries need access to mitigation technologies and an incentive to adopt them. Ongoing work at the OECD is examining these issues.

Likewise, innovation can be better mobilised to propel development and prosperity in the poorest regions of the world. In the agriculture sector in particular, innovation can be a key driver of poverty reduction in rural economies. Policies also need to provide affordable access to communications technologies, especially broadband Internet, which is vital to accessing knowledge and can trigger local innovations, boosting rural development beyond agriculture. Improving rural productivity also requires significant investments in basic infrastructure including transportation, rural energy, and irrigation. There will be little progress without these foundations.

Stimulating entrepreneurship and facilitating private sector development in developing countries should be high on the agenda, as they can promote the autonomy needed to turn opportunity into prosperity. These are important investments, which need carefully tailored incentives and risk-sharing mechanisms supported by government. Donors can play a critical role in priority setting, but also in terms of operations and implementation. To make this happen, links between development policy and innovation policy need to be established, and coherence between the two strengthened.

The notion of innovation has broadened

In recent years, the notion of innovation has broadened. In particular, interest has grown in non-technological forms of innovation – for example organisational changes, marketing and design – and their contribution to productivity growth. This interest reflects a growing appreciation of the interaction between – and complementary nature of – technological and non-technological forms, particularly in terms of wider application and adoption of innovations.

The focus on non-technological innovation has been most prominent in the services sector, which now accounts for more than 70% of GDP in OECD countries. Indeed, empirical evidence shows that innovation in this sector takes different forms than in the manufacturing sector. Services firms innovate through informal R&D, the purchasing and application of existing technologies, as well as the introduction of new business models.

There is a growing recognition that innovation encompasses a wide range of intangible activities, in addition to R&D. Efforts to improve measures of such innovative activity, or show that R&D needs to be supported by a complementary range of other investments, are still underway. Nevertheless, it is already clear that investment in intangibles is as important as tangible investments in machinery, equipment and buildings.

Moreover, the understanding of the innovation “cycle” has grown. The links between policies to enhance investment in the creation and application of knowledge and new technologies, and policies that provide incentives for innovation through to the tail end of the innovation cycle, *e.g.* in supporting demand for innovative goods and services, are increasingly recognised.

The contribution of entrepreneurship to innovation is unique. Innovation often occurs through entrepreneurs’ exploration of new markets, ideas and opportunities. New companies are created to exploit technological or commercial opportunities which have been neglected by more established companies and bring them to market. In 2005, half of business R&D in the United States was conducted by companies that were less than 25 years old. A policy environment that fosters the start-up and growth of new firms is therefore critical to allow innovation to flourish.

Furthermore, networked innovation processes, underpinned by the spread of broadband Internet connections, enable a much larger participation in the innovation process, opening it beyond the realm of corporate R&D laboratories to users, suppliers and consumers in the public, business and non-profit sectors. Tapping into this source of ideas offers a potentially important new source of innovation and enhances the influence of market demand on innovation.

The wider range of actors now involved in the innovation process underscores the need to develop “soft skills” that equip people to work in multi-disciplinary and multi-cultural problem-solving teams. Innovation also involves the capacity to adapt, or to retrain following the introduction of radically new products and processes. Therefore, it is important to ensure that educational institutions, as well as vocational education and training programmes, equip younger people and graduates with flexible and broad skill sets to accommodate the changing nature of innovation.

Community engagement is also important in the uptake of innovation. In many countries, the public is demanding a role in decisions relating to the adoption of new technologies, particularly when these challenge strongly-held values. The backlash witnessed against new technologies such as genetically modified foods is just one example of the role and influence of communities. Early-stage engagement with the public can play a key role in the acceptance of innovations, and can influence the applications derived from new technologies. Drivers of public attitudes towards new technologies and innovative processes – including perceptions of risks and benefits – therefore need to be understood by technology developers and policy makers.

These and other changes in the innovation process present a challenge to existing national policy frameworks, many of which remain primarily focused on strengthening public research and on providing incentives for market participants to invest in research. A shift towards fostering a wider range of innovation activities is needed. Understanding how important such new forms of innovation are, how they interact with each other, and what factors drive them is the key to developing appropriate policies.

Improving the measures of innovation is critical to provide new tools for policy making and evaluation. The OECD and the research community are working to develop a new set of indicators to examine the broader notion of innovation and its link to economic performance and growth. This will require additional collection and use of internationally comparable data at the firm level, as well as a better understanding of currently unmeasured factors in the innovation process.

Innovation processes have become more complex

Just as the notion of innovation has broadened, innovation processes have become more complex and interactive. The production and commercialisation of significant innovations such as the discovery of the transistor, the invention of antibiotics or the introduction of organisational changes in the workplace has never been a simple or risk-free task. But there is now a more explicit recognition that the process of innovation is not merely a linear progression from scientific research to discovery, to technological improvements, to finished products and diffusion.

The complexity and costs of engaging in innovation – in particular at the frontier – have risen. Increasingly, innovations are achieved through the convergence of different realms and technologies (*e.g.* social sciences, microelectronics, engineering and life science technologies). Such innovations promise new added value but are risky, since business models are uncertain, costs are high and new potential competitors emerge in a very fluid business environment. Thanks to decades of trade liberalisation, markets have become more globalised, opening new opportunities, as well as intensifying the level of competition. Product life cycles have also shortened or are under pressure – owing to more intense and global competition and continued technological progress. This is forcing companies to innovate more quickly and develop products and services more efficiently.

These trends have had several impacts on the innovation process. First, innovators have narrowed their focus to those elements where they believe they have a competitive advantage. While science and innovation activities still tend to cluster in particular locations or around certain institutions, other regions are increasingly emerging as a hub for innovative activity.

Second, confronted with intense global competition and rising R&D costs, companies are increasingly collaborating with external partners. The aim is to stay abreast of developments, expand their market reach, tap into a larger base of ideas and technology and get new products or services to market before their competitors. Suppliers and customers are among the most sought-after innovation partners. These networks and ecosystems are increasingly global.

As the practice of “open innovation” spreads, new forms of knowledge sharing and exchange between firms, individuals and institutions are growing. These collaborations are giving rise to “knowledge markets”. Using a number of different mechanisms and platforms, buyers and sellers can pool or trade data, information, contacts and know-how. Steering markets toward innovation and attracting outside investment also depends on an effective and balanced intellectual property regime. All of these mechanisms help to enable the use, sharing, or exchange of information and knowledge.

All of these developments call for individuals and institutions to adopt a more “open” and flexible approach to innovation, where collaboration and competition coexist in the innovation process. For governments, it implies a coherent and interdisciplinary set of policies to foster innovation.

Innovation requires platforms that support the creation and diffusion of knowledge

The capacity to innovate in this dynamic environment depends on many factors, including the infrastructures and institutions that support the creation and diffusion of knowledge on the one hand, and the demand for innovation on the other. On the supply-side, this includes educational institutions that support the formation of human capital, and research institutions and universities, which play a key role in the creation and diffusion of basic knowledge.

Although business funds a greater share of global R&D in comparison to government, public support for longer-term fundamental research in universities and public research organisations remains critical. It is key to developing new scientific and technological knowledge that can lead to innovations to benefit the economy and society. By nature, this type of research has a long time horizon and uncertain returns. Indeed, while business has reduced its investments in basic research over time, it continues to rely on public research for important knowledge spill-overs that can trigger innovation.

On the demand side, market-based institutions, consumers, and entrepreneurship and new firm creation play an important role. But capacity for innovation also relies on linking mechanisms that help match supply and demand, as well as scientific and technological infrastructure and platforms built around general purpose technologies (GPTs), such as information and communications technologies (ICTs), and especially the Internet.

A new and potentially huge driver of innovation is emerging: the demand for processes and technologies to address environmental and sustainability challenges. The search for innovative responses in these areas is likely to grow sharply in the coming years, driving new investment and further exploration of resource and energy-efficient technologies, renewable energies, new business models and cross-sectoral application of ICTs, biotechnologies, nanotechnologies, and others.

Complex market and societal needs often require multidisciplinary, innovative solutions. This calls for more systemic application and diffusion of existing innovations, but also more international and interdisciplinary research and development at the technological frontier. These developments have implications for governance, international collaboration and the mix of skills needed, as well as the costs and risks of engaging in innovative activities.

Governments not only play the role of “rule setters”, but are increasingly a central innovation actor playing within those rules. Demographic pressures, burgeoning demands, higher public expectations and

ever-tighter fiscal constraints mean that the public sector is seeking innovative solutions to enhance productivity, contain costs and boost public satisfaction. The “innovation imperative” is therefore equally strong for the public sector itself. Governments can also contribute to creating demand for innovation through public procurement.

The new innovation governance framework needs to be coordinated and coherent

In this increasingly complex and shifting landscape for innovation, developing an effective governance strategy requires coordination at the local, regional, national and international levels, across a wide range of actors and government ministries – Science & Technology, Trade, Competition, Communication, Environment, Health, Foreign Affairs, Employment and Education.

Yet, achieving co-ordination and coherence is a difficult challenge. Coherence involves not only co-ordination of simultaneous policy actions, but also an evaluation of their possible interactions with policies aimed at other objectives. For example, supporting the growth of young dynamic firms require close coordination between innovation and entrepreneurship policies. Likewise, a closer integration of policies fostering innovation and a cleaner environment can help guide economies towards greater sustainability. In many cases, innovation policy remains compartmentalised in different departments and agencies that face obstacles to co-operation.

In developing their innovation policies, governments also need to consider the need to adapt to the evolving needs of actors in the innovation process over time. Putting in place mechanisms that enable learning and policy development can help ensure that government is effective and efficient in meeting the needs of society in the field of innovation.

A new policy agenda for innovation

The challenge is therefore to adjust the way innovation policies are designed and implemented to ensure they respond to the new landscape. Changes in the way we innovate; the pace of innovation; the need for better risk management tools; the pressures of globalisation, both organisational and in governance; and the growing expectations of civil society, beg the question: are the public policy instruments in use today “right” for the job? And how can approaches be tailored to country specificities: the level of economic development, economic structure and institutional setting? A systemic but flexible strategy is needed to enable governments, firms and individuals to harness innovation for better economic and social outcomes. Key elements of such a policy agenda include the following:

Collaboration and knowledge exchange: Innovators today increasingly collaborate with external partners, including suppliers, customers and universities, to tap into new knowledge, expand their reach or share risks and costs. Policy can facilitate such collaboration, which is increasingly global, for example by lowering barriers to international knowledge flows and by encouraging the development of knowledge markets.

Platforms for innovation: Innovation today relies on networks and institutions that support the creation and diffusion of knowledge and help link the supply of innovation to the market. The Internet and related ICTs are arguably the most important platform for innovation today, enabling flows of knowledge and linking innovators around the world. Policy needs to ensure a competitive environment for the development of these and other technology platforms, with broad access for users. Moreover, while business accounts for the bulk of investment in innovation, government support for longer-term fundamental research remains essential in creating the seeds for future innovation.

Tapping into the global system and building on local strengths: Innovation today is a global undertaking, in particular for multinational enterprises, but is built on local strengths. Drawing the benefits

of the globalisation process for national and local economies requires policies that enhance the attractiveness of national and local economies for innovation, *e.g.* in improving frameworks conditions, strengthening universities and building local networks.

Preparing citizens to participate: In addition to traditional science and technology skills, the competencies that are needed for innovation today have widened to include management, leadership, marketing and business skills, as well as creativity and collaborative and team-working skills. Innovation today crosses borders, mixes disciplines and involves a wide range of actors. Policy makers need to ensure that education and training systems deliver the right mix of skills and competencies needed for innovation, which will require reforms in curricula, vocational training systems and adult learning.

Fostering entrepreneurship: Entrepreneurs are key players in both the supply and demand for innovation. They also help generate competitive pressures on incumbents, forcing them to innovate. Policy can foster entrepreneurship by facilitating the entry, exit and growth of firms, for example in lowering administrative and regulatory barriers, improving bankruptcy regimes and easing access to finance.

Facilitating international co-operation and technology transfer: Innovation can play a major part in addressing global policy challenges, such as climate change, health and food security, as well as poverty. Responding to these challenges will require global solutions and stronger international co-operation. More effective mechanisms for this collaboration, and for the diffusion of innovations as widely as possible, must be developed. Co-operation in research and the development of effective solutions are among the key actions that policy can take to address these challenges.

Enhance the efficiency of policy: Governments have a wide range of policies in place to foster innovation. Improving the design of these programmes, *e.g.* in using competitive processes or public-private partnerships, can help enhance their effectiveness and increase value for money. Evaluation is essential to improve policy making, and this depends on improving the availability of data and the development of indicators that reflect the complexity of the innovation process.

Innovation in the public sector: Government is increasingly a key player in the innovation process. New approaches and new technologies, such as e-government, can help solve problems and improve how services are delivered by increasing responsiveness and improving efficiency and transparency.

Creating framework conditions: The development of innovation policies needs to be supported by conducive “framework conditions” – sound macro-economic policy, competitive markets, smart regulations, openness to international trade and foreign direct investment, a supportive tax climate and a healthy financial system. Government plays an important role in setting these conditions. At the same time, the challenges for innovation policy differ across countries, and policy advice will need to be tailored to the specific needs of each country.

Good governance and strong political leadership: Given the importance of innovation for core policy objectives, and the broad range of policies needed to foster innovation, it is clear that innovation has become a central pillar of government policy. Political leadership in advancing the innovation policy agenda and good governance at all levels of government are therefore of key importance.

These broad principles will be developed over the coming year and complemented with detailed policy guidance that can help underpin the development and implementation of effective, whole-of-government policies for innovation.