Innovation, Competence Building and Social Cohesion in Europe

Towards a Learning Society

Edited by
Pedro Conceição,
Manuel V. Heitor and
Bengt-Åke Lundvall

NEW HORIZONS IN THE ECONOMICS OF INNOVATION

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2. Interactions between policy learning and innovation theory

Lynn K. Mytelka and Keith Smith

This chapter explores links between the development of innovation theory since the late 1970s, and the evolution of innovation policy ideas, primarily in the 1990s. The argument is that there is a close connection between theory and policy, so that theory and policy learning can be seen as an integrated, co-evolving and interactive process. We analyse the theory-policy learning link in terms of two phases. We suggest that the complex economic crisis of the 1970s created an opening for rival analyses of events. During the 1980s, the development of evolutionary theories (pioneered by Richard Nelson and Sidney Winter) and of empirically-based theories of the innovation process (pioneered by Nathan Rosenberg) created a framework in which policy agencies could consider heterodox ideas concerning objectives and instruments of public policy. By the early 1990s policy makers, particularly in Europe, came to see RTD and innovation policies not just as important arenas of action in themselves, but as instruments towards more wide ranging policy objectives. The policy agencies involved, though hierarchical, were characterised by relatively open structures that permitted a degree of intellectual diversity: so organisations like the OECD and the European Commission played a central role, whereas the World Bank, for example, did not. Increasing policy interest stimulated a second phase of research in the 1990s, sponsored both nationally and by various EU programmes, in which expanding the innovation-oriented knowledge base became a significant objective for policy makers. The chapter argues that the theory-policy link has been central to the intellectual development of this field, which would have been impossible within the constraints of existing disciplinary structures and university funding systems. At the same time the analytical achievements have permitted a wide expansion in the conceptualisation of policy targets and in the design of instruments available to policy makers. In a sense, this is itself an evolutionary story: of a crisis and a conjunctural niche that permitted the creation and (so far) survival of a set of diverse and certainly non-conventional ideas.

2.1. INTRODUCTION

The development of innovation theory over the past 20 years has involved a major reformulation, with innovation no longer seen primarily as a process of discovery (that is, of new scientific or technological principles) but rather as a non-linear process of learning. This revision has been powerfully influenced by the work of Richard Nelson and Sidney Winter, whose *An Evolutionary Theory of Economic Change* (1982) proposed the idea that innovation is shaped by crisis-driven search programmes by firms. As existing procedures falter in the face of shifting economic or technological conditions, firms began the search for alternatives, in experimental learning processes. A major theme in innovation research subsequently has been exploration of the nature and characteristics of such learning, across firms, sectors, regions and national systems.

A related theoretical development was the idea that learning occurs in specific institutional contexts: that is, in systemic environments shaped inter alia by regulation, law, political cultures, and the 'rules of the game' of economic institutions. These environments of course include policy institutions and actions. But policy structures are not developed once and for all. Although they exhibit inertia, they also have dynamic aspects, and this dynamism often results from learning – from improved understanding of the agents, interactions and patterns that are the objects of policy. A central component of understanding the dynamics of innovation as a whole should therefore include the nature and effects of learning within policy systems.

There can be little doubt that there has been significant change within innovation-related policy arenas during the last 20 years. This has been a matter both of the objectives and instruments of policy and it has been most pronounced within the Organisation for Economic Cooperation and Development (OECD) and the European Union (EU). In terms of objectives, innovation policy has come to be seen as a central instrument for achieving outcomes that lie well beyond the field of RTD or innovation alone. The concepts and instruments of policy have also shifted, with non-linear models of innovation and the 'innovation system' concept playing a central role in policy discourse, and with a wide range of new policy instruments directed at networking, clustering, and personnel mobility. We argue that this complex process of change can best be understood as policy learning.

Why did these particular institutions become the location of policy innovation? We suggest that in contrast to more hierarchical organisations such as the IMF and the World Bank, access to policy making circles and opportunities for influence have been far greater in these ostensibly weaker siblings over the same period. While in both sets of international organisations, problems growing out of the twin processes of globalisation and rapid technological change were being placed squarely on the agenda from the 1970s onward, more hierarchical organisations retained the macroeconomic perspective and broadly neoclassical conceptual approaches with which they were most familiar.[1] By contrast, faced with the paradoxes of productivity growth in the 1970s, the challenge of competitiveness in the 1980s and the problem of equity in the 1990s, other – perhaps more internally differentiated or consensual – organisations contained niches in which conceptual diversity was possible. The OECD and the European Community contained both staff and national delegates who were receptive to new approaches. Although such diversity was often the object of internal conflict, nevertheless these were organisations that could tolerate a degree of intellectual variety. It was into this breach that evolutionary economists, regional geographers and other students of innovation stepped.

In this chapter we chart the shift towards innovation theory-based policy through a brief examination of the concepts and theoretical approaches introduced into academic debates and echoed in working documents and publications of the OECD and EC a few years later. The questions we address concern the drivers and mechanisms of such learning. The argument in this chapter is that the process of policy learning cannot be separated from the development of the field of innovation research itself. The scale and scope of such research have expanded greatly during the past two decades. Theory and policy are best seen as co-evolving: so this is a process of interactive learning, in which a social science field, and a policy arena, have been jointly and interactively shaped. A primary driver of this has been the long-term impact of the economic crisis of the 1970s.

2.2. GROWTH, COMPETITIVENESS AND INNOVATION: THE REFOCUSING OF A DEBATE

During the 1950s and 1960s, a set of social conventions and economic mechanisms were put in place across Europe and North America that ensured the mutual adjustment of mass consumption and mass production and provided a quasi constancy in profit share with respect to value added. In this way investment was stimulated, but only so long as demand was buoyant. By the 1970s, a crisis was in the making when productivity increases became more difficult to achieve and the growth of demand faltered.

We are still far from a full understanding of the factors that combined to produce this slowdown in productivity growth from the early 1970s. On the one hand, there were a number of major system shocks: the collapse of the Bretton Woods system (itself stemming from a complex financial crisis); the two OPEC oil price shocks of 1973/4 and 1978; and general political instability (including the effects of prolonged war). On the other hand, there were economic and technological factors that attracted little attention at the time, though increasing attention in subsequent decades (Aglietta, 1976; Piore and Sabel, 1984; Boyer, 1988; Freeman and Perez, 1988). The argument there was that on the production side, imbalances in capacity utilisation between highly specialised mass-production machinery, rigidities in supplier-client relationships and management structures, as well as labour problems, all played a role in slowing down the diffusion of productivity enhancing techniques, both material and immaterial. On the consumption side, the crisis of the 1970s led to slower growth in domestic purchasing power and a segmentation of markets into income and product categories within which price and income elasticities of demand differed. Market saturation in many of the consumer durables that had been the staple fare of large corporations also occurred and was exacerbated by rising imports of standardised, mass-produced products from low-wage countries (Mytelka, 1987).

Although the responses by economists to this crisis were primarily macroeconomic in character, the crisis of the 1970s also led to serious questioning of earlier approaches to the analysis of growth. In a 1981 symposium on the consequences of new technologies for economic growth, structural change and employment, Christopher Freeman (1982, p. 1) pointed to the importance that economic theorists such as Adam Smith, Karl Marx and Joseph Schumpeter attached to innovation as an engine of economic growth. But these insights were not part of mainstream growth theory at that time – from the 1950s, the broad conception of innovation as a process of technological and organisational change that these theorists shared had been supplanted by a narrower approach to technological change within a series of macroeconomic growth models. As Richard Nelson cogently argued, the models of the 1950s and 1960s clearly showed their limitations in dealing with the paradox of productivity growth that became apparent in the 1970s (Nelson, 1981) and the challenge of competitiveness in the 1980s. This was partly because of the static, allocative assumptions upon which these models were based. But it was also the result of a dual view of 'technology', seen either as knowledge embodied in capital and intermediate goods, or as exogenous knowledge creation, with knowledge itself seen as akin to information, and therefore a public good.

This simplification allowed technology to be assimilated to any other good or service that could be bought and sold in a market. Information, on the other hand, was regarded as freely accessible and non-rival, in the sense that many people could use that information at the same time without diminishing it. As a public good, its transfer was believed to be costless. On the one hand, this provided a rationale for public provision or subsidy of research, since the public good characteristics of technological information implied a market failure.[2] On the other hand, in growth accounting, knowledge, too intangible to be measured, formed part of the residual (Abramowitz, 1971).[3] Its acquisition was assumed to result from a quasi automatic process of learning-by-doing. Over the next several decades, statistical efforts focused unsuccessfully on reducing the residual by rendering knowledge more tangible. Labour was thus differentiated by skill level and industries classified by research and development (R&D) intensity.[4] But the underlying assumptions – concerning knowledge as a public good and innovation as a process that involved a direct and automatic link between research and development expenditures, innovation, productivity gains and commercial success – remained unchallenged. Empirical research, however, began to cast serious doubt on both the theoretical and practical usefulness of these linear 'research to competitiveness in the market' models.

At its simplest, the development of innovation studies as a field rests on a rejection of the neoclassical growth model, a rejection of implicit neoclassical ideas concerning knowledge, and a rejection of the linear model of innovation. Something that has attracted far less attention is the fact that much empirical innovation research has also challenged the innovation ideas of Schumpeter. The development of the field could be argued to result primarily from two bodies of work. During the late 1970s and early 1980s, there emerged a well articulated evolutionary critique of neoclassicism, in the shape of Nelson and Winter's *An Evolutionary Theory of Economic Change* (1982). This provided a coherent micro-based alternative to the dominant neoclassical paradigm.

Of equal importance, and over roughly the same time period, were a series of chapters and books by Nathan Rosenberg, that significantly shifted the ground in the understanding of innovation, and that have had a powerful albeit indirect effect on policy thinking across countries. In *Perspectives on Technology* (1976) and *Inside the Black Box: Technology and Economics* (1982), Rosenberg addressed an astonishingly wide range of issues to do with innovation. These included a critique of neoclassical concepts of technology; a sustained critique of Schumpeter's invention-innovation-diffusion schema; a broad set of industry studies (woodworking, machine tools, aircraft, electronics, chemicals); important work on the economic role of science (and its relation to technology); and some more or less unique work on factors shaping the direction of specific lines of technical advance. A connecting theme in this work is the rejection of both neoclassical and Schumpeterian notions of linearity. For example, Rosenberg stresses the importance of the fact that innovations, when introduced to the market, invariably require major post-innovation improvements, and it is these that shape adoption. This undermines the distinction between innovation and diffusion, while positively emphasising the need for learning feedbacks between marketing, production and development as a basis for the wider process of innovation. This sustained research programme deserves specific mention because it gave rise to a deceptively simple model of the innovation process that has had a powerful impact on policy makers – the so called 'chain link' model (Kline and Rosenberg, 1986). Some of its applications of this model will be mentioned below.

These pioneering contributions have been followed by a very substantial research programme and literature during the past 20 years. At the risk of oversimplifying considerably, we could sum up some of the results of this literature, and its policy conclusions, around its robust and generally accepted conclusions concerning innovation and its effects. Framed by an evolutionary economics perspective, rejecting all notions of optimal decision making and hence optimality properties in the economic system, non-linear models of the innovation process were developed. Based on the interactive effect between variables as opposed to the impact that any single variable might have in explaining the process of innovation and diffusion, they involve feedback loops between: (i) research; (ii) the existing body of scientific and technological knowledge; (iii) the potential market; (iv) invention; and (v) the various steps in the production process (Kline and Rosenberg, 1986; OECD, 1992b). These models emphasised the uncertainties and unpredictable nature of the innovation process (Rosenberg, 1976, 1982) and stressed the dynamic impact of innovation clusters as opposed to single innovations (Freeman and Perez, 1988). Within these approaches, the firm was reconceptualised as a learning organisation embedded within a broader institutional context (Lundvall, 1988). By focusing on the knowledge, learning and interactivity among actors that gives rise to 'systems of innovation' (Freeman, 1988; Lundvall, 1992, 1995), the new innovation paradigm drew attention to the 'national or local environments where organisational and institutional developments have produced conditions conducive to the growth of interactive mechanisms on which innovation and the diffusion of technology are based' (OECD, 1992b, p.238). The process of innovation thus came to be seen as both path dependent, locationally specific and institutionally shaped.[5]

Among these diverse concepts, and from a policy perspective, the notion of the 'national system of innovation' has had by far the greatest impact, indeed an astonishing take-up. Despite the fact that the notion of system had in fact been widely present in the work of innovation theorists such as Rosenberg, technology historians such as Thomas Hughes, that of the regulation school in France, and in technology systems analysis (Carlsson, 1995), the decisive 'systems' impact on policy thinking came via the work of Bengt-Åke Lundvall (1992) and Richard Nelson (1993). The difference between these volumes can probably best be summed up in terms of two approaches to national systems, described by Lundvall himself. According to

Lundvall a distinction can be made between a narrow and a broad definition of an innovation system respectively:

> The narrow definition would include organisations and institutions involved in searching and exploring – such as R&D departments, technological institutes and universities. The broad definition ... includes all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring – the production system, the marketing system and the system of finance present themselves as subsystems in which learning takes place.[6]

Nelson's *National Innovation Systems* essentially followed the narrow definition. In *National Systems of Innovation*, Lundvall and his collaborators focused much more on a conceptual account of the characteristics and effects of learning. Their definition of a system was as follows:

> ... a system of innovation is constituted by elements and relationships which interact in the production, diffusion and use of new and economically useful, knowledge ... a national system encompasses elements and relationships, either located within or rooted inside the borders of a national state.[7]

In the Lundvall framework innovation is conceptualised as learning, since innovation is – by definition – novelty in the capabilities and knowledges which make up technology. It sought to understand the nature and dynamics of learning via three basic concepts: the organised market, interactive learning, and the institutional framework. What this approach essentially did was to place the empirical work on innovation within a conceptual framework that enabled sympathetic policy makers to challenge (or simply ignore) the neoclassical approach to economic and policy analysis.

This is not to say that the economic mainstream was not changing. This period also saw the emergence of the 'new growth theory' and the 'new industrial economics'. New growth theories have attempted to move away from the earlier linear perspective, to endogenise the knowledge creation process and to relax neoclassical assumptions of perfect competition, perfect information and identical levels of technology (Verspagen; 1992, Romer, 1994). But a fundamental problem is that the conception of technology within these models remains very thin and stylised (Mytelka, 1999, pp. 16–17). Such models did not deal well with the uncertainties and dynamics that characterised changes in production and competition then underway; notably, the increasing knowledge-intensity of production and the diffusion of innovation-based competition as markets liberalised around the globe. They proved unable to incorporate, as the NSI notions did, a variety of ways of understanding the innovation process itself. But while the new growth theories have yet to generate useful guidelines for policy, they have made important contributions to academic debates about the role of innovation in the competitiveness of firms and of countries that emerged in the 1980s. Somewhat similar problems were associated with the new approaches to industrial economics. These approaches introduced far richer concepts of technology, and of the strategic environments of firm decision making. But they retained the notion of optimal decision making by modelling within a game-theoretic context that replaced optimal choice within well defined choice sets with selection of optimal strategies. Some of the key elements that had emerged from empirical innovation research, such as radical uncertainty, interactivity, and clustering issues, never made an appearance.

2.3 LINKING INNOVATION THEORY AND INNOVATION POLICY: THE EMERGENCE OF NEW CONCEPTUAL APPROACHES TO POLICY

During the 1980s and 1990s, the OECD, the EC and UN agencies such as UNCTAD and ECLA took the new innovation paradigm increasingly on board. In part, this involved such organisations taking a wider perspective on the role of innovation policy, and in part it involved changed conceptualisations of the nature of innovation and of appropriate policy instruments.

These changed emphases had their roots in the 1970s. The rather conventional views of the Brooks report on *Science, Growth and Society* (OECD, 1971) began to be supplanted by a new conceptualisation of the innovation process. A key document was *Technical Change and Economic Policy* (OECD, 1980), which was probably the first major policy document to challenge the macroeconomic interpretations of the 1970s crisis, and to emphasise the role of technological factors in potential solutions to the crisis. The group that produced this report was a high powered one, and included a number of figures who were already central to the emerging field of innovation studies, including Richard Nelson, Christopher Freeman and Keith Pavitt. The report looked well beyond the specifics of the energy crisis of the 70s, developing a critique of conventional growth theory. It looked to the impacts of new technologies in ways that have themselves become part of the conventional wisdom in subsequent decades:

> … electronics is the major research-based sector which has maintained, and even increased its innovative vitality. The principal feature has been innovation in the manufacture and design of electronic components. The years from 1975/76 on have seen what has come to be known as a 'microelectronic revolution'. …such radical innovations are bound to have pervasive effects in many sectors where improved methods of calculation, communication, control and the storage and

manipulation of information are necessary or possible. The diffusion of electronics throughout other manufacturing and service industries will result in an economy in which one technology influences innovation almost everywhere. (OECD 1980, p. 48)

This process of analytical change led on to the Sundquist Report (OECD, 1988) which took the need for an integrated overall approach to technological, economic and social issues as its conclusion and stressed that technological change is a 'social process, not an event, and should be viewed not in static, but in dynamic terms' (op. cit., p. 11). Such developments occurred within the Directorate for Science, Technology and Industry (DSTI) of the OECD. DSTI had been established in the early 1960s, and had had considerable success in promoting technology issues (for example, around the concept of the 'technology gap'), and in fostering the systematic collection of R&D data (in the late 1960s, producing the 'Frascati Manual' that became the basic standard for R&D data collection within OECD countries). While the OECD's Economics Department tended to be rather orthodox in its views, DSTI had a place for the heterodox, and such important figures in innovation studies as Christopher Freeman and Keith Pavitt worked within it.

This background within DSTI ultimately formed the basis for a three year work programme known as TEP (the Technology-Economy Programme) which ran from 1989 to 1992. The TEP programme was a loosely coordinated set of conferences, workshops, and data development exercises, accompanied by a rather vigorous process of report production. These had the effect of importing, for the first time, the new ideas circulating in the innovation studies environment, into OECD documents and publications. For example, the major conference report *Technology and Productivity* (OECD 1991) combined extensive econometric and other quantitative analysis of the productivity slowdown with chapters on technology and growth, radical innovations and paradigm shifts in the growth process, networks and innovation, system effects and diffusion. Extensive indicator work within TEP included the *Oslo Manual*, which was explicitly based on the Kline-Rosenberg model of innovation as its conceptual core, and which attempted to expand the direct measure of innovation and of non-R&D innovation inputs (OECD 1992a, 1997).

By far the clearest statement of the new approaches came, however, in the final report from TEP, *Technology and the Economy: The Key Relationships* (OECD, 1992b), a document piloted through OECD by Robert Chabbal, François Chesnais, Bengt-Åke Lundvall, Paul David, Luc Soete and other economists in the evolutionary and institutional economics mode. This document also opened up with the Kline-Rosenberg model as its analytical framework (op. cit. 1992b, p. 25). But it introduced into the policy discussion a wide range of other concepts from innovation studies – networking and clustering, strategic partnering, spillovers, the importance of tacit knowledge. Less tangible in the report, but of greater long term significance in policy discussions, was the concept of national innovation systems, derived from the recently published books by Lundvall and Nelson on this topic. 'When the outcome of this programme was summed up in Montreal in 1991, the concept, national systems of innovation, was given a prominent place in the conclusions' (Lundvall, 1992, p. 5). The dramatic breakthrough represented by the TEP report in the consideration it gives to linkages within national innovation systems (OECD, 1992) was carried through in subsequent OECD policy studies such as the 1994 Jobs Study and the policy recommendations related to learning in the knowledge-based economy contained in its sequels, the 1996 *Technology, Productivity and Job Creation* report, and the 1998 *Technology, Productivity and Job Creation: Best Policy Practices*. It has in fact become a core concept within policy discussion related to innovation, both at OECD, in the EU and to a lesser extent in development studies at UNCTAD and ECLA.

By the last of the OECD studies mentioned above, the transition away from a linear approach to growth and competitiveness based on the stimulation of research and development and its transfer to the productive sector was conceptually complete. The problem itself had been reformulation to include the distributional issues resulting from a process of innovation and technological change and the nature of the solution was conceptually more holistic:

> Today's rapid technological change coupled with the restructuring underway in OECD economies leads some to associate technology with unemployment and social distress. However technology per se is not the culprit. Its economy-wide employment impact is likely to be positive provided that the mechanisms for translating technology into jobs are not impaired by deficiencies in training and innovation systems and rigidities in product, labour and financial markets ... wide-ranging and coherent policy reforms [will be needed] ... to enhance the contribution of technology to growth, productivity and jobs ... innovation and technology diffusion policies themselves continue to be too piecemeal, with insufficient consideration of the linkages within national innovation systems. (OECD, 1998, p. 7)

Directly operational studies such as the OECD Science Policy Reviews, however, failed to make the transition to an innovation focus. Designed 'to produce a friendly but independent and critical assessment of each country's performance against an international comparative yardstick, [in practice they] concentrated mainly on the formal R&D system and technical education'

(Freeman, 1995, p. 30). But their legacy provided a learning experience for UNCTAD in the design of its Science, Technology and Innovation Policy (STIP) Reviews (UNCTAD, 1999a, 1999b). These latter studies were explicitly organised around the national innovation systems concept.

2.4 POLICY DEVELOPMENTS IN THE EUROPEAN COMMISSION

A similar, if slower, process of conceptual change took place within the European Union. Neither industrial policy nor research and development policy were among the areas covered in the 1967 Treaty of Rome. By the early 1980s, however, both had found a place among the European Commission's directorates (Guzzetti, 1995, pp. 1971–83). Cumbersome rule making procedures within the EU were responsible, in part, for this slowness. But it is also important to remember that the first research and technology development (RTD) programmes were designed and implemented in the early 1980s when seminal works in innovation theory were only beginning to appear (Nelson and Winter, 1982; Dosi et al., 1988). With the information technology revolution already underway and evidence of Europe's declining market share accumulating, RTD programmes under the First and Second Framework Programmes were thus designed more for competitiveness than for innovation. This included well known programmes such as the European Strategic Programme for Research and Development on Information Technologies (ESPRIT) whose main goals were: (i) to promote intra-European industrial cooperation through precompetitive R&D; (ii) to thereby furnish European industry with the basic technologies that it needed to bolster its competitiveness through the 1990s; and (iii) to develop European standards (Cadiou, 1996; Commission of the European Communities 1987) and the Basic Research in Industrial Technologies (BRITE) programme, also aimed at enhancing competitiveness.

During the 1980s and well into the 1990s, EU policy makers were hard put to deal with the complex reality that innovation processes represent and tended to fall back upon a simpler 'linear research to competitiveness in the market' model in designing RTD policies whether these were intended to stimulate a process of catching up, keeping up or getting ahead. Thus, as large, diversified Japanese information technology firms accelerated their investment in product and process development in the 1970s and began to move from technological catch-up towards the frontier through collaborative R&D projects, their relatively smaller European rivals, cloistered within national markets, lacking economies of scale and slow to move towards economies of scope, steadily lost competitiveness. In response to this deteriorating situation, the European Communities launched ESPRIT with a pilot year in 1983.

ESPRIT was followed in 1985 by the Programme for R&D in Advanced Communications Technologies in Europe (RACE),[8] the Basic Research in Industrial Technologies (BRITE) programme, 'designed to help the European manufacturing industry to become more competitive'[9] by collaborating in basic research and in the implementation of new technologies by users, and the Biotechnology Action Programme (BAP). Subsequently, BRITE was merged with the European Advanced Materials programme (EURAM) and the range of activities covered by BAP was extended under the Biotechnological Research for Innovation, Development and Growth in Europe (BRIDGE) programme. Up to 1989, all Community RTD programmes, including training programmes such as the Community Programme in Education and Training for Technology (COMETT), aimed at achieving competitiveness by pumping up the supply of RTD and technological skills and somewhat belatedly by stimulating demand for these outputs.

Prior to 1989 all major European Community RTD policies were thus supply side-oriented, dealing with the 'upstream' knowledge inputs provided by research, development and training. Many of the RTD programmes of the early 1990s, such as the SPRINT Specific Projects Action Line (SPAL) which promoted technology transfer across sectors and regions, and the Value programme, set up to diffuse the results of European RTD projects were also supply side-oriented. They recreated linearity by emphasising the outputs of upstream activities such as research and development or end-of-the-pipe products, patents or products, for example, as opposed to the intangible, continuous and interactive processes of 'learning to learn' and knowledge diffusion and absorption which are the bases for innovative behaviour.[10] In what follows we look briefly at an experimental programme of the 1990s, the SPRINT-SPAL from the innovation perspective.

In the innovation literature, interactivity, bottlenecks in production, challenges from other firms in a competitive environment or simply by the availability of new technology are believed to stimulate innovation (Rosenberg: 1976, Lundvall: 1988). But if the firm does not have an experience of innovating and has not built up a culture of innovation or to paraphrase Stiglitz, has not 'learned to learn', there is no guarantee that it will respond positively to such bottlenecks, challenges or opportunities. Small and medium sized enterprises, for example, may not perceive either their own problems or the opportunities that new technology opens up for them. Interviews with firms participating in the SPRINT Specific Projects Action Line, a programme dedicated to technology transfer, revealed precisely this kind of orientation among end users, many of whom were initially either 'unable' or 'reluctant' to appreciate (the) benefits of a technology transfer project (Technopolis, 1994: 27) and were thus uncommitted and reluctant to be involved in demonstrators (Technopolis, 1994: 54). Under such conditions, simply adding end users over the lifetime of a project neither widens nor accelerates the diffusion process.

Firms that are risk adverse, moreover, may be unwilling to take a leap into the unknown without considerable support. For these firms, a minimalist solution of sticking to what is known will be preferred to a maximalist one in which the firm engages in a process of innovation in cognitive frames, work arrangements and cultures. Taking the minimalist approach, however, does not guarantee that the recipient firm has been set on a dynamic path for the future. Yet technology transfer projects are rarely designed to break the non-innovative habits and practices of recipient firms. Rather, to a large extent, by focusing on existing technology, they give the appearance of linearity and certainty. Since the points of both departure and arrival are known, there is a tendency to miss all of the steps in between. Technology transfer thus comes to be viewed as a one time means to upgrade the technological level of a firm by transferring the hardware and software required for a particular production process from one producer to another or between a producer and a user. Conceptualised in this way, innovation is reduced to the introduction of a new product or process into a new setting and technology transfer becomes a vehicle for the promotion of innovation only to the extent that it enables a recipient to learn how to use a new process or to produce a new product. It is grafted upon existing routines rather than entailing any real break with them.

Innovation, however, is much more than this. It involves producers and users in a continuous, non-linear, interactive process of change that leads to new ways both of thinking about and of doing things. This goes well beyond the introduction of new production processes and products to include the development of management routines that are better attuned to problem sensing and problem identification; the revamping of communications channels between production, marketing and R&D; and changes in the organisation of production so as to enhance quality, speed throughput and improve the longer term adaptive potential of the firm. Only a continuous process of innovation enables the firm to deal positively with challenges to its competitiveness as these arise. This is why 'learning to learn' must become a component of technology transfer projects if they are to contribute positively to innovation in the longer term.

Although Commission documents at that time began to reflect the conceptual shift to innovation policy, the design of RTD programmes remained influenced by the earlier supply side orientation throughout much of the 1990s. The SPRINT case study underscored the need to refocus such programmes on the process of innovation and thus upon the habits and practices of the actors whose behaviour policy was intended to influence. It also pointed to the need to replace existing hierarchical models of performance appraisal by more collaborative approaches that stimulated interaction among partners, providing the kind of continuous feedback between partners and monitors that alters not only the goals of a project but the means and routines that govern activity between and within participants.

But despite these limitations at the conceptual and implementation levels, it was precisely within somewhat 'linear' programmes such as these that new approaches to conceptualising innovation and hence re-conceptualising policy approaches emerged. SPRINT was aimed at innovation and technology transfer, but it also incorporated an analysis programme, the 'European Innovation Monitoring System' (EIMS), which became a focus for innovation studies across a wide field of applications. EIMS also became the initiator, together with Eurostat, of the 'Community Innovation Survey', which was based on the conceptual and statistical work initiated by the OECD's TEP programme – so there was a also a general interplay between some of the agencies that were open to the ideas of the new innovation theory. This programme is a good example of a niche area in which heterodox approaches took root, supported and encouraged by small numbers of policy makers and administrators seeking new approaches and tolerant of the complexities and messiness of empirical innovation research.

These EU programmes – and earlier initiatives such as the late 1980s-early 1990s programmes MONITOR (on evaluation) and FAST (on forecasting and technology assessment) provided both research support and a meeting place for European innovation researchers. As such, they played an important role in the evolution of the field, giving it both intellectual credibility and financial support that were crucial to some research institutions. This process can arguably be seen as an example of precisely the type of interactive and feedback-based learning modelled within innovation theory itself. On the one hand there was a supply of new ideas emanating from a vibrant but very small intellectual community. On the other there was a demand for policy solutions to growth and equity issues at regional, national and European levels. But most importantly, there were continuous feedback loops in the form of monitoring and evaluation projects, analysis and development of the results of innovation survey data, and a continuous dialogue between research and policy makers in regional authorities and relevant EU agencies. Continuous interaction and feedback had an important impact on both innovation theory and the world of policy ideas.

But it was not until the focus shifted to regional development policies that the kind of interactions that theory suggested were critical for innovation became more fully integrated into EU programmes. This was reflected in the participatory methodologies used to capture inputs from the demand side adopted in the new regional policies, particularly the set of regional innovation and technology transfer initiatives called RTP, RITTS and RIS. These actions differed significantly from the more traditional RTD policies, from efforts to transfer technology to smaller firms and less favoured regions and from earlier uses to which structural funds were put. To some extent, therefore, the equity issue played the role of a demand side factor in pulling forward conceptual change. Over time, and in parallel with the OECD, the problem was reformulated from competitiveness to innovation and equity, the inter relatedness of policies was given greater consideration and the process itself became more interactive. Social scientists played a major role in this transformation both at the design stage and in undertaking the monitoring and evaluation that provided feedback into the policy process. This kind of interactivity in a sense reflects the interactivity of the chain link model, with feedbacks providing a key dynamics to the overall process; once again, this would suggest that innovative learning and policy learning have fruitful analogies, and cannot be fully separated from one another.

Such processes began to emerge onto a wider stage over the 1990s. In the early 1990s, RTD issues began to play a more significant role both in policy pronouncements, and in the organisation of policy-related research in the EC. The Maastricht Treaty, for example, specifically mentioned the role of R&D policy in industrial change, and regional cohesion; and this theme was repeated in the EU *White Paper on Unemployment*. The OECD programme on unemployment (the 'Jobs Study') in the mid-1990s focused very much on technological change issues. Country-level reviews in the OECD and UNCTAD, statistical indicators collected by the OECD and the EU and the research and technology development (RTD) programmes of the European Union were slowly developed or redesigned to give effect to the insights flowing from innovation theory.

The increasing policy emphasis on the role of RTD was reflected in action. In the EU, the budget of the Framework programmes, the overall R&D programme budget within which 'packages' dealing with the major European-level scientific and technological RTD effort were organised, became one of the few growing areas. The Framework programmes were coordinated and to some extent implemented by DG-XII (now DG-Research). They incorporated a fluctuating array of mainly supply side technology-push programmes dealing with electronics, telecommunications, pharmaceuticals, and industrial technologies.

The really major impulse to the development of innovation research in support of policy came with the 'Targeted Socio-Economic Research' (TSER) programme in the Fourth Framework programme (1995–99), and the follow-up 'Improving Human Potential' programme in the Fifth Framework programme. Here the initiatives lay with policy makers and administrators. TSER was large, carefully designed and rather well prepared by Commission staff who, in general, were well informed and rather widely read within the field. In effect, they took on board the new innovation theories, identified the gaps and weaknesses, and sought to research some of the key unresolved problems. Projects emerged on a wide range of topics: these were usually multi-year projects, with a wide range of partners across Europe, and were well funded (for an overview of some key first round projects, see Archibugi and Lundvall, 2001). TSER contained no less than 64 projects, mostly large scale, and IHP and smaller number of large scale projects (European Commission 2000, 2001). They included such topics as:

- innovation in service industries
- innovation systems and European integration
- new innovation statistics and data
- S&T policies in transition countries
- institutional restructuring in transition countries
- public participation in environmental policy
- modelling sustainable growth in Europe
- universities and technology transfer on the periphery of Europe
- economic analysis of technology, economic integration and employment
- strategic analysis: policy intelligence and foresight
- regional innovation systems and policy
- multimedia and social learning
- financial systems and corporate governance (focusing on its effects on innovation)

This kind of wide ranging support has continued, and has produced a very substantial change in the character of innovation research in Europe (Bartzokas, 2001). Every significant institution working in the innovation field in Europe has participated, and virtually every significant researcher. The level of networking and contact between researchers has multiplied dramatically, as have the number of journals and the volume of publication. So these EU-backed projects have provided a major dynamic impetus to innovation studies, as well as providing a practical level of support without which some key institutions in the area might not have survived. This ought to be seen as a reciprocal movement out of the impact that innovation theorists had on policy in the 1980s and early 1990s; the EU programmes really represent an interactive mix of concepts and policy approaches.

2.5 CO-EVOLUTION OF THEORY AND POLICY – THE GAPS THAT REMAIN

Innovation theories emerged in a period of dramatic change. Expectations were diminishing after a sustained period of post war growth. Technological ruptures were underway but their impact on productivity was far from being felt. Imports from low wage countries were increasing and, coupled with new patterns of investment and organisational change, created further economic dislocation as regions declined and unemployment rose. Existing theory could not deal with these changes and the paradoxes to which they gave rise. While national governments in the developed world initially fell back upon neoprotectionist solutions and then embraced liberalisation, a small number of international organisations such as the OECD and the EC, became the locus for exploratory thinking around the issue of technological change. Dissenting theorists slowly reformulated the problem as one of learning and innovation and contextualised it in terms of innovation systems and institutions. Passage through international organisations then served to legitimise these concepts and to promote them as focusing devices in national policy making.

In this process, and despite their 'outsider' status, social scientists working within the new innovation paradigm have been extraordinarily successful in building a constituency for innovation systems approaches and in the design and redesign of innovation policies. By emphasising the contextually specific nature of innovation processes, they have brought theory closer to policy, but have not entirely bridged the gap. Nor has the emphasis on a holistic and differentiated approach implicit in the innovation system literature made the task of its use in the development of policy *instruments* any easier. Evolutionary theory, for example, 'would predict that different actors would do different things. They would see opportunities differently. They would rank differently those that all saw' (Nelson, 1996, p. 125). We would thus expect national governments to tailor new policy instruments to the particular habits and practices of actors whose behaviour policy is designed to influence. Only where stakeholders at the regional level have been able to shape policies directly through participatory processes are there small signs of movement in this direction. For the most part, policy makers have been hard pressed to deal with the complex reality that innovation systems approaches represent.

The absence of a unified theory that relates innovation to growth and distribution and links macro approaches to the micro level has slowed the application of innovation theory to policy areas beyond the narrow confines of education or research and technology development policy. Similarly, the lack of new measurement tools has limited the translation of innovation theory into effective policy instruments. This contrasts with the impact of Keynes' theory which was reinforced by the concurrent development of national accounting statistics that made it possible to quantify the analytical categories of his *General Theory*, to estimate empirically the functional relationships between them and to apply the theory to the resolution of policy problems (Patinkin, 1976). Concurrent developments to measure innovation have been undertaken in the 1990s. Paul David, Richard Nelson, Bengt- Åke Lundvall (who in fact made the transition from researcher to deputy director of DSTI in OECD between 1993 and 1995) and Luc Soete were among those who played a role in efforts at the OECD and in the EU to build an empirical base for the analysis of innovation. But these efforts have yet to provide the tools, for example, to test the OECD's conceptually interesting hypothesis that a system's innovative capacity is related to the extensiveness and efficiency with which it distributes and absorbs knowledge (David and Foray 1995).[11] As this chapter has shown, although innovation theory has made considerable conceptual inroads, there is still a way to go before the links between innovation and other policies are well established and the ability to measure the results becomes a reality.

The story we have sought to tell here is itself an evolutionary one. Learning in this field has been interactive, with a strong co-evolution of policy ideas and theoretical and empirical studies of a new field. As with other processes of economic evolution, this has been problem-driven, indeed crisis-driven. Despite the now dissipated euphoria associated with the 'new economy' of recent years, the past three decades have been a time of economic turbulence, with sustained problems of unemployment and productivity growth. This has created a niche for new ideas, and the interaction of policy needs and intellectual endeavour has created a space in which the new field could grow. Simultaneously, and probably for similar reasons, the mainstream of economics has declined, and that discipline now faces its own crisis of declining student numbers and diminished policy credibility. It is of course impossible to say how this situation will pan out. In our view, much will depend on the ability of innovation studies to remain an area of intellectual vitality and advance, something which will require a clear recognition of existing limits and weaknesses, and a clear willingness to seek to overcome those limits.

NOTES

1. Despite extensive criticisms of the IMF/World Bank structural adjustment programmes, the IMF response to the Asian financial crisis, for example, carried forward its traditional approach. Even the presence of an 'outsider', Joseph Stiglitz, as chief economist of the World Bank brought little by way of change in conceptual frameworks or policy approaches in this institution and virtually no ability to influence practices in the World Bank's sister institution, the IMF.
2. The classic statement of this point was Arrow (1962).
3. Abramowitz (1956) found that barely half of the actual growth in output could be explained by the growth of inputs in terms of capital and labour. The residual was classified as unexplained total factor productivity.
4. For an excellent review of the earlier economic literature flowing from the initial work of Moses Abramowitz, see Nelson (1996). In a more recent article Nelson has carried forward his critiques to deal with the 'new' growth theorists (Nelson, 1998).

5. Although as Saxenian (1994) and Storper (1999) have argued, these localities are not restricted to national spaces.
6. Lundvall op. cit., p.12.
7. Lundvall, op. cit., p.2.
8. RACE began with a definitional phase in 1985–87 and a main programme from 1988–92. Under the Fourth Framework programme for research and technology covering the years 1994–98, RACE because the Advanced Communications Specific Programme whose aim is 'to consolidate European technology leadership in digital broad band communications' (I&T Magazine, DGIII & DGXIII, Spring, 1994, p. 4).
9. *Innovation and Technology Transfer Newsletter* (Commission, DGXIIID-2): Vol. 14/1 (3/93), p. 12.
10. Only the Telematics program, the Sprint MINT program which helped small and medium sized enterprises (SMEs) absorb new technology and some of the newer BRITE/EURAM projects in this period, seemed to reflect primarily a demand side orientation. They were not, however, truly 'interactive'.
11. The tendency, therefore, has been to recreate linearity in formal models and to rely on the indicators used by more conventional approaches. Thus, attempts to operationalise the distribution power of innovation systems, that is, 'the proportion of knowledge "ready for distribution"', use output measures such as publications and patents, common to other approaches and measure the absorptive capacities of firms, as elsewhere, by quantitative indicators such as the amount of in-house R&D (in value or numbers of scientific and technical employment) and the cost of technology licensing.

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