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Policy Relevance and Theory Development in Innovation Studies

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POLICY RELEVANCE AND THEORY DEVELOPMENT IN INNOVATION STUDIES

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INTRODUCTION

New conceptual and analytical approaches for restructuring technology and innovation policy have been developed in both industrialised and developing countries. To a large extent, these ideas are still strongly tied to the academic world with limited accessibility to policy analysts. Many recent works in Technology and Innovation Policy research have adopted economic or quasi-economic metaphors for understanding policy processes. However, these metaphors are generally not fully elaborated. A dissonant counterpoint to the shortcoming of overly abstract remedies is provided by examples of empirical research where adherence to commonly accepted theoretical assumptions interferes with proper appreciative diagnosis of the problem in the first place. As a result of recent empirical and analytical work, the institutional and economic aspects that theory and empirical research ought to address are much more clearly defined. This interdisciplinary and empirical research oriented approach provides useful insights and concepts for practices and routines in the conduct of Technology and Innovation Policy.

This paper presents a brief review of the evolution of ideas of the Economics of Technological Change in the broad area of industrial structure, innovation dynamics and economic performance. Our emphasis is on contributions which might have policy relevance when it comes to the design and implementation of innovation-related policy. This review provides the general context for the discussion of some of the research findings of the European Commission Targeted Socio-Economic Research (TSER) Programme in the area of national systems of innovation. Finally, the paper explores a number of directions for further work in the area of innovation-related policy oriented research.

INNOVATION STUDIES AND THE ECONOMICS OF TECHNOLOGICAL CHANGE

Since the early 1960s, a number of scholars, motivated by the inadequacy of conventional microeconomic approaches to technological change started what has since then become a tradition of empirical studies on the behavior of innovative firms. Pioneering work on these lines started forty years ago. It was the first step towards what is now being called “appreciative” theory of technological change and started with empirical work on innovation and technological change at the sectoral level. These studies have provided valuable information on how industrial structures evolve together with technological change. Current research in this direction suggests that research on technology issues should focus on the behavior of firms and sectors in relation to their national institutional contexts (the national systems of innovation approach). In recent years, these research findings have been incorporated in analytical-theoretical structures which try to explain the nature of innovative behavior of firms and the role of technological change in sectoral trajectories and macroeconomic dynamics¹.

Looking back in the late 1950s, the introduction of growth models had little to do with how things are being done (the production process). Even in the case of the literature on the strategic importance of trade and technology flows, the emphasis was firmly based on final products. Of course, the line of research which was developed by a small number of scholars in the Allyn Young tradition took notice of the implications of the fact that different production processes are associated with different productivity levels at the sectoral level. In the area of business economics a distinctive research tradition emerged which established the case-study approach in issues linked to industrial organisation, capabilities at the firm level and corporate performance. Early attempts for the convergence of different approaches were introduced with analytical work on the organizational characteristics of corporate capabilities, the theory of the firm and empirical studies which examined the link between case studies, sectoral technological trajectories and productivity². A different approach was introduced by Paul David with the development of a non-neoclassical evolutionary approach to induced technical change. He

¹ An account of research findings since the 1950s is provided in Richard Nelson (1995) Co-evolution of Industry Structure, Technology and Supporting Institutions, and the Making of Comparative Advantage, *International Journal of the Economics of Business*, Vol. 2, no. 2, pp. 171-184. For a collection of recent contributions, see Gilberto Antonelli and Nicola de Liso (1997) *Economics of Structural Change and Technological Change*, Routledge, London.

² Penrose, Edith, (1959), *The Theory of the Growth of the Firm*, Oxford University Press and Freeman C., Young, A. and Fuller, J.K. (1962), The Plastics Industry: a Comparative Study of Research and Innovation, *National Institute Economic Review*, Vol. 26, pp. 22-62.

introduced the concept of a variety of production processes that could be designed with the existing state of knowledge and the concept of localized learning which directs technical change. David differentiated his approach from neoclassical production theory by suggesting that substitution in the production function may involve an element of innovation. The primary significance of this contribution is that it opened the door, and identified most of the elements, of what has since become known as the path dependent model of innovation³.

In the 1970s, the world economy went through a difficult adjustment process and the issue of the efficiency of the economic system came up as one of profound interest for academic research and policy makers. This was a period of high expectations for researchers working in the broad area of the Economics of Technological Change. The main contributions, at that time, were the institutional interpretation of the low rate of productivity in developed countries and the empirical studies on the contribution of technological capabilities to the catching-up process in developing countries⁴.

The introduction of the concept of techno-economic paradigms by Freeman and Dosi in the early 1980s, which has evolved to what in our days is known as National Systems of Innovation, was an extension developed by evolutionary theorists to what was already suggested by Passinetti in his model of demand driven structural transformation⁵. The systems of innovation approach deals with institutional arrangements –including rules and rule making agents- that regulate interaction inside and across the boundaries of an economic system. The emphasis is on the analysis of innovation dynamics of the economic system and many authors share the view that an institutional perspective on innovation dynamics should also address questions of efficiency and performance⁶. We can summarise the implications for policy of this approach in the following way: the need for change is being introduced to the economic system either through changing demand patterns or through technological breakthroughs. What determines an efficient adjustment and what promotes growth and welfare is the way in which institutions adjust to these changes.

This research tradition moved on to two different directions. The first one was a purely empirical one: firm level/sectoral case studies⁷. The second direction developed the micro-

³ Paul David (1975) *Technical Choice, Innovation and Economic Growth*, Cambridge University Press.

⁴ For a survey of this debate, see Chris Freeman (1994) *The Economics of Technical Change: A Critical Survey*, *Cambridge Journal of Economics*, Vol. 18, pp. 463-514.

⁵ For a representative paper of the debate at that stage, see G. Dosi (1988) Sources, Procedures and Microeconomic Effects of Innovation, *Journal of Economic Literature*, Vol. 36, 1126-1171.

⁶ See, for example OECD (1997) *National Innovation Systems*, OECD Publications. For a review of the most recent literature, see Daniele Archibugi, Jeremy Howells and Jonathan Michie (1998) *Innovation Systems in a Global Economy*, CRIC Discussion paper no. 18.

⁷ See, for example, Mark Dogson and Roy Rothwell (eds.) (1994) *The Handbook of Industrial*

foundations of a dynamic evolutionary approach with the development of existing elements of evolutionary and institutional theory on the behaviour of firms within their institutional setting⁸. Both directions were reactions, of different kind, to systemic complexity. This brings us to the problems of socioeconomic research when it deals with complexity. The usual reaction is to start by narrowing down the boundaries of the system itself before going on to the elaboration of causal linkages and analytical hypotheses. Two problems emerge from this approach. First, technological change is being understood as the driving force of dynamism in the economic system. In many cases, scholars accept that this empirical observation has the value of an axiomatic assumption and some go one step further by assuming that this is a well established causal link and, at the very end, a smooth process. Second, the relevance of this concept to empirical research becomes problematic when it is being used for the interpretation of exogenous shocks to economic activity which, by their nature, go beyond already established boundaries.

The attempt by economists and political scientists to develop an institutional theory of the dynamics of the economic system goes back to T. Veblen and his 1898 essay on “*Why is Economics not an Evolutionary Science?*”⁹. This project was abandoned by institutional economists in the US when they came to realise that it was very difficult to develop methodology and measurement techniques which could deal with the interplay of institutions and change in economic systems. It was then suggested that each change is by hypothesis a unique event, caused by an indefinite number of causes and it was stressed that without the aid of elaborate techniques it would be very difficult to advance the knowledge on the problem of institutional change beyond the insights provided by Veblen¹⁰.

These endemic problems in systemic theorising might help us to explain the weak link of this theoretical tradition to empirical research in recent years, the difficulty to offer testable hypotheses and the failure to predict recent developments in industrialised countries¹¹. Therefore, we suggest that there is increasing need to integrate policy-oriented research in the broader territory of innovation and technological transformation studies in industrialised

Innovation, Edwar Elgar.

⁸ Richard Nelson and Sidney Winter (1982) *An Evolutionary Theory of Economic Change*, Harvard University Press.

⁹ Reprinted in *The Place of Science in Modern Civilisation*, Russek & Russek, New York, 1961

¹⁰ Quoted by M. Rutherford in Veblen’s Evolutionary Programme: a Promise Unfulfilled, *Cambridge Journal of Economics*, 1998, Vol. 22, pp. 463-477. For a detailed and balanced review of the recent literature, see Richard Nelson (1995) Recent Evolutionary Theorising About Economic Grange, *Journal of Economic Literature*, Vol. XXXIII (March), pp. 48-90.

¹¹ See John de Mothe (1998) National Innovation Systems, “Real Economies” and Instituted Processes, *Small Business Economics*, Vol. 11, pp. 101-111 and Wilkinson, F (1983) Productive Systems, *Cambridge Journal of Economics*, vol. 7, pp. 413-430.

countries. This approach will bring the output of academic research closer to a better understanding of economic and technological trends¹².

In an attempt to explore the feasibility of this argument, I would like to turn to the parallel development of theory and empirical work in two other directions: growth theory and industrial economics. In both cases we have seen a regeneration of interest, the emergence of significant debates and a re-evaluation of neoclassical models. This re-examination has been stimulated by the concern that neoclassical models are inconsistent with the evidence. Some examples will illustrate this point. Research is shifting from the focus on what determines growth rates of a group of countries to what influences the growth rate of individual countries and from the link of market conditions to innovation to the interlinkages between firms, market conditions and corporate performance. In both cases there is an increasing recognition that applied research reinforces theory and that realistic assumptions might offer a way out of declining returns of research efforts in areas such as the cross country regression analysis studies¹³.

What needs to be examined, though, is to what extent these recent contributions provide opportunities for complementarities to the results of innovation studies. Indeed, recent work in growth theory has emphasized the contribution of (a) externalities resulting from capital and knowledge accumulation, (b) accumulation of human capital, and (c) continuing growth in the stock of productive “designs” with the stock of “codified” knowledge facilitating mechanisms capable of generating long-term economic growth. This approach justifies a role for policies that affect efficiency of resource use such as co-ordination of investment decisions, investment in infrastructure and education as well as the development of science and technology policies. At about the same, scholars working on industrial dynamics from a Schumpeterian perspective -- mainly in the fields of trade theory and technological diffusion -- moved to analytical models and research methodologies which are closer to the conventional approach of the Economics of Technological Change.¹⁴

¹² For a review of the evolution of thinking in advanced countries in this direction, see Keith Smith (1997) *Systems Approaches to Innovation: Some Policy Issues*, TSER-ISE Project, processed paper.

¹³ See, for example, Milgrom, P. and Roberts, J. (1990) The Economics of Modern Manufacturing, *American Economic Review*, Vol. 80, pp. 511-528, and Jonathan Temple (1999) The New Growth Evidence, *Journal of Economic Literature*, Vol 37, No. 1 (March), pp. 112-156.

¹⁴ See, for example, Gene Grossman and Elhanan Helpman (1992) *Innovation and Growth in the Global Economy*, The MIT Press. A first attempt to present this trend in a text-book was made by Stoneman (1995) *Handbook of the Economics of Innovation and Technological Change*, Blackwell Publishers.

Regarding industrial economics, we suggest the following classification of the evolution of academic research on issues related to industrial organisation and wealth creation¹⁵. The first one is the static resource allocation approach with optimum properties of competitive markets which reached their finest theoretical formulation in the model of general equilibrium. It has been suggested by theorists in the Arrow-Debreau tradition that this model is a valuable tool for descriptive analysis at a higher level of abstraction, a first axiomatic approximation, which will progressively be removed to reveal a durable building which could encompass descriptive analysis (the “calibration” stage). Our review of the technological studies literature suggests that the problem with this approach is that more and more axioms and special assumptions have had to be added and whenever empirical research (not to mention policy research) have tried to introduce inescapable characteristics of the real world, i.e. increasing returns, imperfect competition, unforeseen technological change, path dependency trajectories, the construction bursts asunder and the building itself collapses. The other set of issues is the causes and consequences of growth dynamics and technological change, their relationship to the process of structural change, distribution and investment decision which includes an account of endogenous technological change. The first set of issues dominates economic research. Some recent studies take it on step further suggesting that this line of research is going through a significant transformation of its axiomatic formalism in model-building. While it continues to be based upon individual optimisation, it now takes account of social institutions and structures by assuming that they are endogenous factors in the economic system. Once there is an endogenous growth mechanism in place, attention can focus on any market imperfection that affects the savings rate and long-run growth prospects¹⁶.

In order to meet these challenges, we have to bring theory closer to empirical research, if only because it might help us to ask the right questions. We don’t suggest that a convergence of methodological assumptions is feasible. However, we think that there is scope to explore the potential of a comparative analysis of research findings from different analytical approaches¹⁷.

Indeed, three areas, in which convergence of different approaches is taking place have emerged:

- a) The strength of evolutionary models lies in the insistence of its practitioners on the importance of the sequence of specific micro-level “historical” events. In this theory, current choices of techniques are the link through which economic conditions and

¹⁵ See also Nicholas Kaldor (1996) *Causes of Growth and Stagnation in the World Economy*, Cambridge University Press.

¹⁶ See for example many recent articles in the *Journal of Economic Growth* and for a critical review, see Ben Fine (2000) Endogenous Growth Theory: a Critical Assessment, *Cambridge Journal of Economics*, Vol. 24, pp. 245-265.

¹⁷ For further discussion on these issues, see Vernon Ruttan (1996) *Sources of Technical Change: Induced Innovation, Evolutionary Theory and Path Dependence*, University of Minnesota, Economic Development Center, Bulletin Number 96-4.

accumulated knowledge may influence the future dimensions of technology and knowledge. But there is little discussion of how firms escape from these lock-in situations. Take for example the case of an industry which enters a constant or decreasing returns stage. Relative factor prices would have the effect of biasing technical change along the lines suggested by the theory of induced technical change¹⁸.

- b) In the field of industrial organisation and especially in the area of the links between industrial dynamics, market conditions and diffusion of technology a clear convergence is emerging between different approaches¹⁹.
- c) Empirical research on industrial structure and innovation dynamics has reached a level of maturity which can have a positive contribution to theory development. The strength of empirical research on industrial organisation and technological change has been its emphasis on production processes and real conditions of production. In this direction, the debate on corporate competencies and technological capabilities has been proliferating. What is missing though is the introduction in the framework of these studies of demand-driven and/or exogenous shocks and the issue of corporate finance (external finance and working capital). Many recent contributions have suggested that the introduction of the issue of resource mobilisation requirements can provide a framework on innovation and technological accumulation at a level of analysis which will establish the link to the macroeconomic environment²⁰.

This comparative perspective is a difficult and challenging task for researchers. However, we should keep in mind that it is the framing of research questions in the context of the constraints dictated by scientific research programmes that transforms questions and puzzles into well-defined problems and extends the problem-solving capacity of them. The fact, for example, that research on innovation and institutions is widely used and it is being considered as a significant contribution to the current debate on growth and competitiveness is not a matter of putting forward novel new ideas, but a matter of suggesting a solution to a problem by incorporating it in an already existing research tradition. This in itself is an important lesson about criteria for theory choice²¹.

¹⁸ For similar arguments, see S. Martin and J.T. Scott (2000) The Nature of Innovation Market Failure and the Design of Public Support for Private Innovation, *Research Policy*, Vol. 29, Nos 4-5 (April), pp. 437-448.

¹⁹ See Paul Stoneman, Technological Diffusion in Neo-classical Type Models: Theory and Empirical Evidence in A. Bartzokas (Ed.) *Industrial Structure and Innovation Dynamics*, forthcoming, Edward Elgar.

²⁰ See, for one example of a recent attempt in that direction, Mary O'Sullivan (1998) *The Innovative Enterprise and Corporate Governance*, TSER-CGEO, processed paper. These issues are discussed in more detail in A. Bartzokas (Ed.) *Industrial Structure and Innovation Dynamics*, forthcoming, Edward Elgar.

²¹ For the implications of these statements, from a methodological point of view, see Patricia Northover (1999) Evolutionary Growth Theory and Forms of Realism, *Cambridge Journal of Economics*, Vol. 23, pp. 33-63.

THE TSER SYSTEMS OF INNOVATION RESEARCH AGENDA

Many different assumptions and methods of research have been introduced in TSER projects by proponents of the systems of innovation approach in recent years. The comparative analysis of different levels of systems of innovation is the first line of research followed by TSER projects. Some of these studies adopted a problem-oriented perspective and they have addressed issues related to the way that different components of systems of innovation are functioning in the EU integration process. It has been argued that integration will affect innovation both because there is a tendency towards an increasing collaborative use of accumulated knowledge for innovation and a better environment for the diffusion of innovation. As a consequence, institutional innovations might be needed to make use of the potential for interactive learning across national borders²².

Another interesting contribution has been the increasing focus of demand aspects of R&D and technology in driving innovation forward in EU countries. These efforts are aimed at understanding phenomena that are difficult to account for by utilising frameworks that emphasise the supply side of national R&D systems. Charles Edquist introduced the concept of “public technology procurement” in the TSER project “Innovation Systems and European Integration”. It draws attention to the fact that technology procurement is a process widely practised within market economies. The comparative study of the EU experience suggested that a common issue encountered in all cases was the importance of “early and sophisticated” demand for the development of new products. The study examined the issues of structure and dynamics in buyer and seller markets and concluded that monopsony can provide strong “demand pull” but tends to encourage rigid supplier-buyer relationships, which may suppress, not encourage innovation. What is most fundamental is the creation of institutional frameworks and organisational forms that will enable users and producers to acquire the necessary knowledge and competence. Institutional frameworks that facilitate the transfer of relevant knowledge work, over the longer term, to create balance and interaction between the competencies of “buyers” and “sellers”. The study made practical suggestions on the role of public agencies charged with carrying out technology procurement projects. It was recommended that they should have sufficient autonomy to conduct technological initiative

²² Bjorn Johnson and Birgitte Gregersen (1997) *European Integration and National Systems of Innovation*, TSER-ISE, processed paper. The authors pointed out that when it comes to the evaluation of the implications of the EU integration process, some aspects of the performance of innovation systems such as the distribution between incremental and radical technical innovations and the amount of organisational innovation are still statistically unknown.

informally during earlier stages of development. This means that higher level political decision-makers are confined primarily to acting in a supportive capacity at later stages by resolving conflicts through formal institutional means²³.

Another TSER project examined the link between institutional change and economic recovery in Eastern Europe. Diverse patterns of emerging systems of innovation have emerged as an outcome of the interaction of organisational path-dependency, recombination of existing competencies into new organisation forms and radical transformation of economic activity generated by new incentives and opportunities. One of the main findings of this project was that it is not yet possible to talk about national or regional systems of innovation in Central and Eastern Europe. The only emerging clusters of innovation activity seem to be around foreign firms, and in some cases around large domestic business groups. Systems of innovation are in the process of articulation through a period of intensive trial and error by enterprises, governments and foreign partners²⁴.

A second group of studies emphasized the dynamics of the evolution of systems of innovation and they have examined some of the main driving forces in this process. They made attempts to solve the difficult problem of monitoring empirical trends either with the case study approach or with the development of new data sets through innovation surveys and fieldwork²⁵. Patent citations have been used to identify knowledge flows between firms. However, very little of this research has attempted to determine the modes and the mechanisms of communication that actually permit knowledge to flow. Furthermore, most of the work in this area has simply assumed that citations or other proxies are sufficiently correlated with knowledge flows to allow statistical analysis of the proxies to be informative regarding the underlying trends. Overall, significant progress has been made in the measurement and analysis of knowledge flows between different institutions involved in systems of innovation in the EU. Some of these results are of major relevance to policy making. Take for example, the issue of the nature and extent of contribution of academic research to innovation. The evidence indicates that a major part of the contribution of academic research is not directly through the provision of

²³ See Charles Edquist, et. al (1998) *Findings and Conclusions of ISE case studies on Public Technology Procurement*, TSER-ISE Project, processed paper.

²⁴ For a presentation of the findings of this project, see Slavo Radosevic (1999) Transformation of Science and Technology Systems into Systems of Innovation in Central and Eastern Europe: the Emerging Patterns and Determinants, *Structural Change and Economic Dynamics*, Vol. 10, pp. 277-320.

²⁵ Rinaldo Evangelista, Tore Sandven, Giorgio Sirilli and Keith Smith (1998) Measuring Innovation In European Industry, *International Journal of the Economics of Business*, Vol 5, No. 3, pp. 311-333. The authors provide an overview of the sources available for monitoring the trends of innovation performance in the EU. In fact TSER funded research on these issues, provided the market for extensive use of the Community Innovation Survey and other specialised data bases.

immediately applicable ideas but indirectly through the adoption of skills, techniques, and professional networks created through academic research. Furthermore, both the bibliometric and the survey based evidence shows that there are strong linkages between business and basic research in universities and public institutions which reflect the fact that they involve the transmission of tacit knowledge through personal contacts²⁶.

Theoretical work on the rationale for innovation-related policies received a lot of attention in TSER projects. In line with other recent contributions, it has been argued that the characteristics of the innovation process have implications on sectoral innovation failures and for the selection of the most effective form of public support for business sector innovation. The terminology might be different but the basic line is that the prevalence of market/systemic failures in innovation and learning processes implies the need to establish a long-term institutional framework for the support of innovation²⁷. The advantage of modern industrial economics is that theoretical models offer useful insights in that direction by describing markets in terms of detailed assumptions about strategic variables, information sets and solution concepts. In order to use these insights, policy oriented research should take explicit account of features of the real world. In that case, the extent to which a selection mechanism will be applied directing resources to each area will vary with the sources of sectoral failures.

One important area examined in the TSER Programme is the role of innovation in services. The framework for comprehending the emerging patterns of innovation in services is the concept of innovation induced changes in the production and delivery of services. This approach highlights the increasing role of knowledge as a source of value across the production chain from the R&D laboratory to the production process. In this broad perspective, innovation is shaped by general characteristics of the competitive environment. This reinforces the view that innovation is a market driven process and it opens up the possibility for new insights for a wider understanding of interactive innovation in European economies. With the emergence of knowledge markets, knowledge intensive services appear as bridging institutions in national innovation systems. Innovations are seldom limited to a change in the characteristics of the product itself. Innovation in services extends from incremental introduction of new ways of distributing the product and new ways of interacting with the customer to complex and pervasive innovations that affect all actors in a value chain in a fundamental way. These may require innovation to take place in subsequent elements of the value chain. The case studies of

²⁶ Pari Patel (1998) *Indicators for Systems of innovation and System Interactions*, TSER-IDEA project, No. 11.

²⁷ Compare, for example two TSER reports: Keith Smith (1996) *Public R&D Policy, European Integration and European Innovation Systems*, TSER-ISE, processed paper and Franco Malerba (1997) *Public Policy and Industrial Dynamics*, TSER-ISE, processed paper with a recent review

services sectors supporting innovation processes across Europe found out that such service firms are enhancing the innovative capabilities and the efficiency of distribution networks that traditionally were in the domain of the public technological infrastructures, extension stations and R&D institutions. Therefore, the provision of services for innovation plays an important role in localised innovation systems and that creates the need for a reconsideration of innovation policies²⁸.

The study of sectoral systems of innovation in many TSER projects provides useful illustrations of the potential value of a more general model of the linkages between industrial organisation, institutions and innovation dynamics at the sectoral level. At a rhetorical level, these studies identify their methodologies with the evolutionary approach. In practise, however, they utilise an eclectic combination of industrial dynamics, evolutionary and path dependence interpretations of sectoral technological development²⁹. A more rigorous approach to the development of a general theory of the sources and the direction of technological change will be required to bridge elements of these three different analytical approaches. The theoretical work sketched in the previous section of the paper and drawn from an evolutionary perspective is in principle consistent with the broader institutional analysis of systems of innovation. Indeed, because of the extent of case-study work devoted to sectoral trends in the TSER Programme, it would be useful to make an effort for the provision of a more structured interpretation of empirical findings. This seems to be a necessary next step if we would like to sustain the productive momentum that has taken place in the field of industrial organisation case studies and sectoral systems of innovation.

In summary, a number of general analytical frameworks have been developed in the context of the TSER programme in order to improve analysis and understanding of systems of innovation in Europe and their implications for individual firms, sectors and countries. Some issues and questions concerning these frameworks have been addressed by researchers involved in TSER projects. In an attempt to develop further the methodological assumptions of the national systems of innovation approach, Stan Metcalfe distinguishes four kinds of influence on innovation activity: (a) the opportunity to innovate in terms of the acquisition of unexploited knowledge, (b) the distribution of incentives to innovate, (c) the distribution of resources

of innovation policy justification(s) from an industrial economics perspective in S. Martin and J.T. Scott op cit.

²⁸ Johan Hauknes (1998) *Services in Innovation – Innovation in Services*, TSER-SI4S, Final Project Report. This line of research has been extended in another on-going TSER project on Research and Technology Organisations in the Service Economy. The new project has proposed a methodology for analysing knowledge intensive services which allows “tacitness” to be recognised for its major role in market transactions.

²⁹ See, for example, the methodological framework of the ESSY-TSER project in Franco Malerba (1999) *Sectoral Systems of Innovation and Production*, ESSY Working Paper No. 1.

available to invest in innovation, and (d) the capabilities of the relevant organisations to develop innovation strategies and manage the process of innovation. A further dimension of the innovation system perspective is the way in which opportunities, incentives, resources and capabilities are open to systemic influence. This perspective takes the discussion on the interaction of different components of national systems of innovation one step further by addressing the problem of what difference the systems perspective might make to innovation. In this dynamic context we need to know the connecting flows, linkages and interaction in order to understand how innovation systems co-develop with the relevant market systems. A second generation of systems thinking in innovation studies has been proposed which should address the rationale of the systems perspective, the interrelationships between different parts and the quality and efficiency of systems of innovation³⁰.

Another proposed extension of the systems of innovation debate refers to the introduction of an industrial-organisation perspective to the study of innovation processes. This approach has criticised the systems of innovation approach for focusing only on interactive learning among firms in an industry rather than on the dynamics of an innovation process characterised by an interaction between accumulation of knowledge within enterprises and cumulative and collective learning across enterprises. It has been argued that the conceptual framework for linking innovative enterprise and corporate governance is the presentation of the innovation process in terms of its implications for the allocation of corporate resources. According to this approach, the innovation process requires financial commitment, organisational integration and strategic control. Indeed, there is a need to identify the location within the functional and hierarchical division of labour of those within the enterprise who make strategic decisions concerning the allocation of resources. The scale of innovative investment thus depends not only on the size of the investment in productive resources and in the abilities and incentives of learners, but also on the duration of the investment necessary to sustain that process over the period during which learning occurs³¹.

The second line of research is addressing the needs of the policy implementation process. In this case, the emphasis is on the development and the improvement of tools for the design and introduction of innovation-related policy. With these studies, the systems of innovation approach provides a convenient and operational set of ideas and policy recommendations. The introduction of innovation and technology policy related initiatives in the US, for example, was influenced by the widely diffused systemic views on comparative advantage and technological leadership in the late 1980s. The shift to diffusion-oriented policies in the EU was also

³⁰ B. Andersen, J.S. Metcalfe and B.S. Tether (1999) *Distributed Innovation Systems and Instituted Economic Progress*, TSER-ESSY, processed paper.

influenced by similar considerations. Indeed, the strength of the systems of innovation research agenda, when it comes to policy implications, is the pragmatic assessment it can provide in the development of a policy framework for selection and fine-tuning of innovation-related policies³².

Margaret Sharp at SPRU is coordinating a large-scale comparative project on the co-evolution of Science, Technology and Broad Industrial Policy in the EU. The country case studies in this project, provide clear indications that strategic goals, organisation and management of innovation related activities in the EU are undergoing fundamental changes. While the pro-market tendency has been widely adopted since the early 1980s, it seems that innovation related policies have substituted the more direct interventions in the industrial domain and they continued to increase well into the 1990s, certainly if one takes account of the emergence of a technological dimension in regional policies. The study applies the concept of government failures due to several types of insufficiencies in the design and implementation of these policies and found out that not much attention is paid in the development of specific objectives incorporated in the design and implementation of policies. In all the country case studies, a convergence of science, technology and industrial policy has taken place but there remains insufficient integration of policy thinking³³.

On the basis of a combination of ideas coming out of evolutionary economics and the sociology of technology, TSER funded research has introduced a paradigm of technology policy assessment that integrates supply and demand side concerns into socio-technical strategies where technological and social measures become amalgamated. The construction of large-scale infrastructure projects, for example, is contained within the logic of governmental decision-making, but at the same time is strongly influenced by professional and institutional interests. This means that development of technology operates on a long time-scale and the interaction of demand and supply factors leads to the transformation of criteria to evaluate successes and failures within technology policy regimes³⁴.

Another comparative study examined the characteristics of the public sector research activities in the EU. Public research in Europe has a wide range of functions and research collaboration is

³¹ William Lazonick and Mary O'Sullivan (2000) *Perspectives on Corporate Governance, Innovation and Economic Performance*, TSER-CGEP processed paper.

³² For a detailed presentation of the impact of the systems of innovation approach on the formulation of technology and innovation policies in advanced countries, see the special issue of the OECD *Science, Technology and Industry Review*, no. 22.

³³ Margaret Sharp, *Progress Report* and Jacques De Bandt (1999) *Interim Report on Objectives of Industrial and Science and Technology Policies*.

³⁴ For an application of this framework to the analysis of how various countries have sought to tackle the problems of traffic and transport in the EU, see Boelie Elzen (1999) *Dimensions in an*

increasing. All the countries involved in this study traditionally invested in public research to advance knowledge and to promote economic development. The main trends which emerged from the case studies are the slow but steady erosion of “block grant” systems in favour of competitive applications for grants, and a growing role of regional institutions as funders of research. Faced with static Government resources, public research institutions have been encouraged to look for new sources of funds from the EC Framework Programme, Structural Funds and the business sector. Common trends are apparent in management practises across countries and it seems that they are converging. One important recommendation is that the growing involvement of public research institutions in application-oriented or strategic research demands that governments should strike a balance between overall coordination of the public research effort and integration of relevant research within relevant ministries. The study also stressed the need to correct the current over-emphasis of EU public research systems on the promotion of industrial innovation. It was pointed out that concentration on short-term issues of current concerns to industry may lead to neglect of longer term research³⁵.

An area for further consideration is the availability of appropriate models for evaluating systems of innovation. A number of basic questions related to growth and welfare, hinge on understanding how innovations occur and how these innovations improve productivity and competitiveness. The answer to these questions are of intrinsic interest but they should address, at the same time, the critical issue of evaluation of government policies that affect innovation either in a direct or in an indirect way. For instance: what are the benefits and costs of tougher patent protection, and how they are shared among developed countries? Do EU countries recover the cost of giving research expenditures tax incentives or the benefits are dissipated through the diffusion of innovations? What are the gains from the integration process of European research and educational institutions? To what extent the integration process will spread the benefits of innovation and technological change for EU economies? How might innovation-related capabilities be reallocated in Europe? What would be the impact of these trends on the distribution of income in the EU? Irrespectively of the position we are taking on the possibility of an optimal path of resource allocation regarding these challenges, policy-oriented research should address these problems in one way or another.

The third line of research is more concerned about model building, either in the context of the innovation-driven growth approach or with the development of the micro-foundations of institutional arrangements governing the development and the trajectory of systems of innovation. At the first level of analysis, TSER projects have developed further the concept of

the “learning economy” and the characteristics of innovation processes in this context³⁶. In response to these challenges a reassessment of the factors that influence capabilities in this area is needed. Knowledge is increasingly being recognised as a fundamental determinant of competitive advantage. Therefore, a strategy to advance the EU in the knowledge-driven economy has to be both comprehensive and coherent. It will not be enough to target a few high-tech sectors or to improve the quality of human capital. In many respects, these are necessary conditions for progress. The key point, however, is that a policy framework in which decisions affecting demand-side are taken without considering the supply-side will have limited positive effects on the competitiveness of the EU³⁷.

Analytical work on the interaction of institutions and innovation starts with the disagreement with the assumption that a common production function is available to all countries regardless of human capital, resource or institutional endowments and the asymmetries between firms and between countries in scientific and technological capabilities. The strength of evolutionary models on systems of innovation is precisely in the area of modeling the behaviour of agents - where qualitative studies are weakest. It builds on the behavioral theory of the firm in an attempt to provide a more realistic description of the internal workings of the technological change ‘black box’³⁸. However, the micro-foundations approach has not received much attention from qualitative studies in the TSER programme as a productive source of hypotheses for empirical research³⁹. It is possible that this lack of interaction between model building and empirical studies could be explained by the fact that evolutionary methodology lends itself to the proliferation of plausible results in comparison to parallel developments in the area of “stylized facts” of industrial organisation and innovation dynamics in advanced countries.

Empirical research on systems of innovation in Europe has reached a level of maturity which can have a positive contribution to theory development, understanding of empirical trends and policy. And these policies have the potential of exercising significant influence on the

³⁵ J. Senker, et. al (1999) *European Comparison of Public Research Systems*, TSER–Changing Structure, Organisation and Nature of European Public Research Systems, Project Report.

³⁶ See B-A Lundvall and Susana Borrás (1998) *The Globalising Learning Economy: Implications for Innovation Policy*, Office of the Official Publications of the European Communities, EUR 18307.

³⁷ For a comprehensive framework of demand and supply oriented policy for a sustainable innovation driven path in the EU, see Bart Verspagen (1999) *Technology, Economic Integration and Social Cohesion: the Policy Challenges* (policy report of the TSER project Technology, Economic Integration and Social Cohesion).

³⁸ See Gionanni Dosi and Richard Nelson (1994) An introduction to Evolutionary Theories in Economics, *Journal of Evolutionary Economics*, vol. 4, pp. 173-184 and for a recent attempt for the incorporation of elements of the organisational approach, see Benjamin Coriat and Oliver Weinstein (1999) *Organisation and Institutions in the Innovation Generation: Towards a Theory of “Corporate Systems of Innovation”*, TSER-ESSY, processed paper.

development and utilisation of knowledge. The importance of these mechanisms goes beyond the diffusion of innovation and the efficient adoption of new production techniques. It extends to the whole fabric of the economic system and triggers policy changes on broader aspects of economic activity. The chances of enhancing the policy relevance of theory and empirical research can be greatly improved by initiating an open dialogue with scholars from different disciplines and policy analysts. This process will provide useful insights for policy-oriented research in the area of innovation, technological change and competitiveness in Europe.

The systems of innovation research effort in the framework of the TSER programme is, in terms of allocated resources and involved academics, a large scale initiative at the international level. These research findings could provide valuable inputs to the framework needed for the assessment of policy priorities in at least two sets of policy problems. The first one is the issue of institutional learning from policy implementation and the second is the economic assessment of innovation-related policy instruments. As well as providing a basis for better policy analysis, these research findings will also define areas for improvement of future research agendas for research on the theoretical, institutional, and policy issues underlying technological change and on the role of technical change in fostering economic growth in the long run.

³⁹ One noteworthy exception is the TSER-DYNAMO Project which explores further this perspective.

THE POLICY RELEVANCE OF INNOVATION STUDIES⁴⁰

There have been four major shifts in the knowledge-based economy since the early 1980s which governments have had to take note of. The first is in innovation and technological change, which firms increasingly depend on for their competitiveness. A major priority of government-backed research must be to enrich the global knowledge base by backing science and technology in universities and research institutions, encouraging exploration of uncertain and untried scientific and technological areas, and training future employees. Facilitating the diffusion and application of knowledge is another priority. Governments can encourage this by providing an appropriate legal and institutional framework for the knowledge-based economy, to underpin the commercial use of intellectual property, for example.

A second shift in the knowledge-based economy has been the growing acceptance of the principle of a ‘learning society’. Most governments are now grappling with how to implement life-long learning. Improving vocational and technical training is necessary in most countries, while increasing mobility between vocational/technical and conventional academic studies is desirable. All countries could benefit from enhancing the links between business and education.

A third new development is reflected in attempts by governments in many different countries to improve their policies for small businesses and to unlock the bottlenecks, which they frequently encounter. Measures recently introduced include: improving access to finance, technology and innovations; developing human resources and management capabilities; promoting networks and alliances; and encouraging the diffusion of best business practice.

A fourth important shift, which the knowledge-based economy has brought about, and one that has accelerated the pace of globalization, is the acceptance by governments of the need to reduce unnecessary public-sector intervention. Most governments now believe that their influence is best deployed to increase flexibility and encourage innovation and competition.

Technology and innovation-related policies can play an important role in advanced countries under different technological, institutional and political conditions. It has been argued that this process is not only beset with dynamic market imperfections associated with learning but static ones also, such as those associated with co-ordinating competing investments as well as co-ordinating firm-level investment to achieve optimal scale. In a world with limited malleability of resources, positive transaction costs will constrain the firms from making bargains which

⁴⁰ This section of the paper draws on discussions and drafts that have been prepared for editing work –jointly with Morris Teubal—on a forthcoming special issue of the *Journal of the*

allow the externalities associated with technological learning and market co-ordination to be internalized, and therefore relying on the market will result in sub-optimal outcomes. In addition, recent work in growth theory has re-emphasized the contribution that investment makes to technological change and thus emphasizes the impact of investment in both physical and human capital on long-term economic growth. This creates a role in the long-run growth process for policies that affect efficiency of resource use such as co-ordination of investment decisions, investment in infrastructure and education as well as the development of science and technology policies⁴¹.

In this context, policy initiatives have had a central role in the evolution of national science and technology capabilities, both in the development of underlying knowledge bases, and in the provision of the physical and knowledge infrastructures on which technological progress depends. This makes the task of state of the art policy research on conceptualizing the appropriate rationales for the priorities of policy an important one, as a precondition for the much more demanding question of the efficiency of policy instruments and implementation methods.

The challenge of innovation and technological change to traditional methods in economics and other social sciences has been a fertile research programme with a broad and diverse collection of theories and empirical research projects, including evolutionary economics and studies of national, regional and sectoral aspects of national systems of innovation. Since the late 1980s, these approaches suggest that research on technology issues should focus on the behavior of firms (and sectors) in relation to their national institutional contexts. This is an especially important consideration, since nearly all the advances in matters of industrial technology policy have come from an improved understanding of how firms operating in market economies deal with issues of technological change. Indeed, policy research on technology issues in relation to industrialization and competitiveness has recently focused on institutional contexts for science and technology at national level. Government policies that are based on a sound understanding of technological innovation and diffusion processes in the private sector create an environment in which these processes can flourish. This is a considerable development of approaches which have up until now focused too narrowly on firm behavior without exploring the role of institutions and science and technology policies.

For a start, governments have moved away from the old protectionism and reactive approach of attempting to save or protect domestic industries and jobs against the tide of globalization and liberalization. Many past practices, such as those of targeting established sectors and firms, or

Economics of New Technology on the political economy of technology policy.

⁴¹ For a useful review of these arguments, see Michael Stolpe (1995) *Technology and the Dynamics of Specialisation in Open Economies*, Tubingen: Mohr.

attempting to pick future winners, have been largely abandoned. Instead, policy is increasingly setting itself the task of creating general conditions which encourage entrepreneurship and innovation, the development of new products, new ways of marketing and producing, even encouraging the birth of whole new activities. Technology and Innovation related policies can be thought of as a specific set of policies that aim to improve the ability of firms to compete by promoting technological improvements through the generation, diffusion and adoption of process, product and organizational technological changes. In practice all the above policy instruments are used simultaneously since, to a large extent, they are complimentary and in isolation they would not achieve the desirable results. For example, in order to set incentives for technological capability building and for the exploitation of scale economies, attention needs to be given to export promotion policy even in industries that are at the infant stages. Entry and capacity regulation need to be used to minimize the dangers that import substitution policies may lead to firms operating at a sub-optimal scale. Still for another example, the role of performance standards needs to be examined in ensuring the maximum gains from state-created rents.

The current debate on policy issues revolves around the problem of the justification of policy interventions and to a lesser extent it takes account of criteria for the design of policies instruments. The existing literature deals with these problems either in the market failure framework or in the evolutionary tradition of institutional adjustment to exogenous changes. The first direction of research suggests criteria for allocation of research and the second perspective emphasizes the importance of a systemic view of institutional adjustment which eventually will inform policy making by providing “best practice” models/routines of involved agents and institutions.

We would argue that the better design of policies extends beyond a set of criteria for resource allocation or the better understanding of the complex interaction of institutions. What is really needed is to bring together specific economic trends and the set of relevant policies, which will address challenges in the economic system in an integrated and efficient way. We take the pragmatic view that governments have policy agendas and they implement them. The scale and/or the extent of these projects is not that important from an analytical point of view. What is more important is to try to link policies to existing and emerging needs which arise from economic and technological trends. Hence, the point of departure is the processes of transformation of the economy at different phases of economic development and industrialisation. A second level of analysis is to identify the relevant policy issues which arise from empirical work on specific aspects of development and structural transformation. The third level of analysis should provide pointers or insights into possible policy conclusions, a process which may require for example linking with the macro-level (when we deal with

problems related to allocation of resources) and/or assuring the co-ordination of the different actors.

Changes in the external and internal environments of the economic system necessitate a re-orientation of what traditionally was termed "Technology and Innovation Policy". Changes in the environment include the acceleration of the globalization process, acceleration in the diffusion of Information Technologies, enhanced liberalization and the enhanced interconnectedness of the global system.

While technology and innovation policy in the past has to a large extent focused on "incentives" to technological development through the stimulation of adoption of new technologies, learning and R&D (either in the context of horizontal programs relevant for the whole business sector or "targeted" programs which are specific to particular sectors or technologies) it is now imperative to take a much more broader perspective which encompasses both a "broad definition" of 'technology policy' (to include in the definition aspects of Science, Technology, Innovation and Industrial Policy), interactions between such an area of policy and other areas such as Foreign Trade, Taxation & Macroeconomic policy; the adoption of broad conceptual frameworks which are *both* Evolutionary and based on a Systems Perspective, and the explicit analysis of *the policy process*.

We suggest that there are three main requirements to the adoption of Technology and Innovation Policies adapted to the new set of conditions prevailing at the beginning of the millenium:

- *New Knowledge*- policy must be considerably more knowledge intensive than in the past and this points out to the important role that research including Academic Research could play in the new context;
- *New Conceptual Frameworks*-broadly speaking what is necessary is a shift to an Evolutionary and Systems Perspective which a) from the "positive side" will consider not only technological development (and R&D) per se but also *learning; co-evolution* between the business enterprise sector, the supporting structure and policy; *etc* and b) from the "normative side" adopt a *strategic perspective*, a view of the policy-maker as *adaptive rather than maximizing*; consider the *policy process* as part of the dynamics of this system;
- *New Policy Mechanisms*- to stimulate the *creation* of such knowledge and its *effective utilization* and translation in terms of national priorities for Technology/Innovation Policy; *translation of priorities* into a set of new 'incentives' programs and institutions; and to assure effective *feedback* between policy implementation and policy formulation.

All of this means that policy-oriented research cannot be viewed simply as being 'implications of theory or of empirical analysis'. This in turn implies a new perspective on the methodology of research which is supposed to underpin policy. This Policy Framework should consider or relate to a number of approaches to Innovation and Technology Policy, including Evolutionary and Systems of Innovation approaches. Thus, several programmes should be designed following innovation policy views which emphasize the critical importance of learning processes, of both enterprises and policy-makers. Moreover, the policy portfolio of a country should aim at inducing a 'desirable' transition of the country's system of innovation, one which reflects the new conditions in the external (and maybe internal) environment facing the country.

CHALLENGES AHEAD FOR POLICY-ORIENTED RESEARCH

Radical changes in the external sector of countries are forcing a reconceptualization of two crucial links present in the innovation process. The first concerns the fundamental interdependence which underlies the relationship between innovation (technological, organisational and in productive capacities) and competitive performance. The second focuses on the virtuous, but also on some vicious, circles which can result from distinct forms of regional economic integration (as venues for international insertion) and the attainment of international competitiveness. These linkages between processes of innovation, competitiveness and regional integration are, in turn, forging novel organisational and market strategies. The latter are pursued by both states and enterprises as a response to major changes in world market conditions.

Governments in advanced countries face many challenges which have a bearing on policy design and implementation. Yet there is no denying the need for new policies and some common principles are discernible which will help governments to build them. The purpose of policy-oriented research is to review the work of social science studies and science policy experts in order to develop a constructive debate on the promises and problems of alternative theories of the development and implementation of Technology and Innovation Policy instruments. The first job is to improve policy design and delivery. This means clearly identifying policy objectives, defining the rationale for policy actions, and setting them in a flexible, though robust, policy framework. From the outset policy makers should think about how to bring business and other interested parties into the process. And once the framework is in place, policies should be monitored and assessed constantly to improve them and to provide feedback into the policy-making process.

Increased co-ordination between national, regional and local authorities in the design and implementation of policies and programmes is another important component of any successful strategy. Co-ordination improves the scope of policy, and helps to reduce duplication and inefficiency. Although collaborating and networking are established practice among private firms, governments in industrialised countries are only now emphasising them in their relations with business associations, financial institutions and public and private bodies. This is evident in new initiatives to help small businesses, where industry associations, research organisations, governments and educational institutions work in partnership to provide intelligence on technology and crucial business services.

A third step is to find ways of making business and industry policies work alongside other policies. Policy formulation is a holistic exercise, and policies can no longer be viewed in isolation. For instance, education and training are increasingly important in industrial and economic policies. In addition, seeking a balance between policies promotes social cohesion and growth. Finally, learning from the experience of other countries is always important, but never more so than in these times of change. International comparisons help governments to identify where reform and improvement are most urgent, and where particular measures might succeed or fail. There is a wealth of experience in different countries on improving policies and the overall business environment. The value of sharing such experiences should never be underestimated. After all, when it comes to business policies in the global knowledge economy, governments too must be ready to learn. This also means looking outwards, taking into account the liberalisation of trade and investment, and new openings in capital and product markets, rather than adopting a purely domestic orientation.

The main characteristics of policy-oriented research addressing these issues are:

- (i) Long learning processes in the implementation of research agendas. Research output takes time and it involves a lot of field work which is always confronted with uncertainties.
- (ii) Policy research is an activity which generates many externalities. These externalities extend from the development of new research tools and data sets to the introduction of new perspectives to current economic and technological problems.
- (iii) Science and Technology policy research is an open-interdisciplinary process. Several disciplines overlap and in some areas of research, interdisciplinary research is already important. There is a possibility of a more objective and certainly more independent view of some fundamental issues than from within one discipline (i.e. economics).

These insights are directly relevant to my last point: the need to reconsider current views on the design of policy-oriented research. In this paper we have suggested that for the implementation of policy-oriented research, a tradition of an objective and well documented research agenda is essential. For that purpose, it is important to understand theory development and empirical research as part of a converging process instead of considering policy-oriented research as an *ex-post* application of theory and model building. These challenges dictate a new structure for policy-oriented and policy-relevant research. Rather than a linear process starting, in the case of qualitative studies, with empirical research aimed at linking competitiveness and economic performance to technological capabilities (in a comparative perspective and aimed at identifying “best practice”) followed by very abstract and un-grounded “policy implications”—a new type of link between positive and normative economics is required. It is a more

integrative link where policy considerations may have to enter even in the initial stage of empirical research; and where “appreciative theory” may have to be developed to define the questions, explain the facts and to answer the various why’s of the process of economic and technological transformation. Moreover, a conceptual policy framework may be required to translate the empirical findings into --among other things-- a new portfolio of programs supporting either innovation in advanced countries or the institutions supporting industrial restructuring in industrialising countries. All of this means that policy oriented research cannot be viewed simply as “implications of theory or of empirical analysis”. This in turn implies a new perspective on the methodology of policy-oriented research which will “lay the empirical basis for a better theory”⁴².

⁴² Richard Nelson (1999) The Sources of Industrial leadership: a Perspective on Industrial Policy, *De Economist*, Vol. 147, No. 1, pp. 1-18.

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