The Organization of Economic Innovation in Europe

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Aims of the book

Why a book on the organization of innovative activity in Europe? While one can think of several obvious reasons (the topic is important, interesting …) there are more subtle reasons as well. Europe is a large economic area similar to the United States, but unlike the United States it is an amazingly heterogeneous continental economic system, with considerable diversity among countries and regions in terms of income *per capita*, industrial structure, specialization, institutional setting, culture, and history. This diverse set of countries and regions is linked together by a supra-national institution, the European Union, which governs the unified market and monetary union, and aims at economic efficiency, social objectives, and dynamic progress in the continent as a whole. In science, technology, and innovation, the European Union also acts as an organism for fostering European cooperation, standard-setting, and advancement of key scientific disciplines and technologies. In all these dimensions one finds the advantages of scientific, technological, and productive specialization among countries and regions, and the disadvantages of increasing economic gaps between strong and weak areas, as well as duplication of resources and activities at the national level. These (and other) conditions imply rather marked differences with other countries, and particularly with the more homogeneous areas of the United States and Japan. This also implies that in analyzing the organization of innovative activity in Europe one cannot neglect this interplay between diversity of contexts and socio-economic environments that are nonetheless linked together by a unified market and a common supra-national political institution.

In this respect, it is surprising that in the field of industrial economics

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there have been so few attempts to build analytical frameworks that are based on the distinctive features and institutional characteristics of Europe, including the peculiar role of the European Union. The neoclassical approach in industrial economics has developed several sophisticated tools to analyze microeconomic behavior at the level of firms and industries (agency theory, contract theory, game theoretic models of strategic interactions, etc.). But the theory was built with a special institutional framework in mind – the United States or, more generally, the Anglo-Saxon system. Similarly, the evolutionary approach has gone a long way in trying to understand learning processes, firms' competencies and routines, industry dynamics, and the role of institutions in economic evolution. But there has been no systematic attempt to cast this approach in the special conditions of the European environment. The evolutionary approach and developments in system theory have developed the concept of "national and local systems of innovations," which has led to numerous studies of individual European countries and regions. There have also been studies that have provided a comprehensive framework of the characteristics of European industries in different countries, and have compared the differences among them. However, there is still a long way to go in order to assess the specificities of the European system as a whole, and particularly of the special role of the European Union with respect to the American and the Japanese cases, or to the emerging economies.

In looking at the organization of innovative activities in Europe, there are some questions that one may still need to address. How does the considerable heterogeneity of firm sizes, competencies, industry structures, and national environments affect the specialization of firms, their growth, degree of vertical integration and diversification, innovative performance, and innovation strategies? How does the fragmentation of the continental market affect the organization of innovative activities and the dynamics of industries – compared with the more homogeneous continental American market or the large Japanese market? How different is the pattern of entry of new innovators across European countries? How important is innovation-clustering in key European regions? How are networks of innovators organized and how industry-specific are they? What are the implications for innovation of the Union's role as a source of allocation of resources for invention?

This book will not give comprehensive answers to all these questions. Nor does it offer a comprehensive description of the organization of innovative activities at the firm or industry level through a complete set of industry or firm case studies. The book does not look at the international performance of European industry (although some lessons can be drawn from this collection of studies); it is simply an attempt to look in a new way

at the organization and dynamics of innovative activities in Europe, by drawing from recent theoretical and empirical literature in the economics of technological innovation.

In recent years there have been several developments in the economics of technological innovation that have examined many aspects of the innovation process, firms' strategies and organization, technological environment, relationship between innovation and industrial dynamics, institutions, and science. First, many studies have emphasized the importance of firms' *learning, routines, and competencies*. Learning is one of the key dynamic mechanisms of firms' knowledge-accumulation, innovation, and growth. Routines have recurrent and automatic action patterns of firms and have an organizational dimension. Competencies underpin persistent differential performance among firms. Competencies are, moreover, often of a tacit nature, they cumulate over time and create persistent heterogeneity and distinctive competitive advantages among firms. Competencies affect the ability of firms to innovate in certain directions rather than others, and shape their technology strategies.

Second, the link between *innovation and industrial dynamics* has been increasingly at the center of analyses. Innovation has been interpreted as the driving force of industrial dynamics, affecting entry, firms' growth and diversification, and changes in market structure. At the same time, technological change has been closely connected with the evolution of firms' learning and competencies and with their innovative behavior.

Third, other studies have highlighted the *sectoral-specificity of industrial and technological change*. The idiosyncratic features of technologies and the technological environment (so-called "technological regimes," defined in terms of the knowledge base and of opportunity, appropriability, and cumulativeness conditions) are major determinants of differences in the patterns of innovation across industries.

Fourth, a great deal of effort has been spent in trying to understand aspects of innovation such as *interactive learning, local externalities, and networks* among firms and other organizations. These aspects emphasize the "system view" of the innovation process, which has implications for the accumulation of technological capabilities, the organization of innovative activities, and the geographical agglomeration of firms.

Finally, recent work in the *economics of science* have discussed the economic implications of the distinctive features of organizations such as universities and other non-profit research centers for the generation and diffusion of innovation, and more generally for the growth of scientific and technological knowledge.

These are heterogeneous approaches. However, they share a common evolutionary framework. Change is at the center of the analysis and

uncertainty surrounds the outcomes of firms' actions. Industrial dynamics is characterized by the generation of innovations and the entry of new firms which increase variety in the system, and by selection mechanisms that in turn reduce the variety of products, processes, and firms' heterogeneity. More broadly the evolution of industries is characterized by path-dependent processes and the coevolution of technology, firms' behavior, competencies and organization, market structure, and institutions. This book shares this framework and presents a collection of theoretical and empirical studies in these areas applied to the European scene. It thus builds on concepts such as learning, competencies, technological regimes, interaction, and networks, and addresses broader issues such as increasing returns, variety, and selection.

We initially thought to make all the contributions in this volume more homogeneous in terms of their approach to the problem, and in their methodological background. We then realized that this would not do justice to the fact that a field such as the economics of innovation has prospered *because* of its variety of viewpoints and contributions. Therefore, although the chapters have been revised several times to find common themes and a consistent overall structure among the various contributions, we deliberately chose to maintain a variety of perspectives in order to take advantage of the richness of ideas, topics, and insights that can be created by an underlying diversity of approaches and methods.

We are not disappointed with the outcome, and we think that one important aspect of the volume is that it looks at the organization of innovative activity in Europe from several viewpoints and tackles different analytical and empirical dimensions. Indeed, the book touches upon issues such as the sectoral and geographical patterns of innovative activities in Europe; the role of large innovative firms, the way they accumulate and use their internal competencies, and the factors that influence their ability to create competitive advantages; the rise of and the opportunities of growth for new innovators, and more generally the extent to which Europe benefits from the creation of new firms that threaten the position of established producers in given markets and industries; technical progress, localized learning, and corporate change in electronics and mechanical engineering; the formation of geographic clusters in Europe, and the role of inter-firm linkages; the structure and dynamics of innovative networks in some key sectors such as software and biotechnology; science–technology interfaces and the evolution of research networks, including universities; and finally the role of the European Union in encouraging the formation of these networks at the European level. Whenever possible, the chapters also present comparative analyses with respect to the United States and Japan.

The structure of the book

The book is divided into two parts. Each part corresponds to a general topic and deals with some special features of the organization of innovative activities in Europe.

Part I focuses on the *patterns of innovative activity in Europe*. This introduces the reader to some of the main features of the European system of innovation, such as the role and characteristics of large firms and the formation of their technological competencies; the vitality of the European innovation process through an analysis of the entry and exit of new and old innovators; the patterns of geographical agglomeration of innovation activities, and the importance of localized vs. generalized technological change.

Part II focuses on *inter-firm collaborations and research networks*. This is a key topic in Europe. While in the United States collaborations among firms have always been treated with suspicion because of their inherent relationship with collusion, Europe has more often regarded collaboration as a means for encouraging effective sharing of complementary resources. Moreover, as noted earlier, unlike the American antitrust authorities, the European Union is especially keen on encouraging collaborations among firms and other organizations of different member countries. This part of the book then examines in some detail the relevance of networks of collaborations among firms and other organizations in the innovation process and the dynamics of research networks in Europe.

Part I begins with an introductory chapter by Giovanni Dosi and Luigi Marengo. *Dosi and Marengo* emphasize in chapter 2 the key role of knowledge in the competitive outcome of individual companies, sectors, regions, and countries. They claim that the specificity of learning, knowledge-accumulation, and competencies is a primary determinant of the observed patterns of innovative activities of firms and industries, organizational forms, dynamics and revealed competitive performances. Learning tends to be technology- and firm-specific, and is also affected by the market and institutional environment. Among the characteristics of the learning processes, three are particularly relevant: path-dependency, locality, and tacitness. Chapters 3 and 4, by Keith Pavitt and Pari Patel, and by Franco Malerba and Luigi Orsenigo, look at two different aspects of the patterns of innovative activities in Europe. *Pavitt and Patel* focus on large firms. They use comprehensive data on patents to discuss how large European firms learn about technologies, how they form their competencies, and their patterns of technological diversification. One of their main conclusions is that in-house learning is an important determinant of the accumulation of such competencies. *Malerba and Orsenigo* examine the entry and exit of firms in different patent classes in Europe. They look at whether new

innovators in a certain class are newly established firms or constitute lateral entries from firms that already innovate in other fields. They also look at the patterns of exit from given patent classes, and examine the characteristics of what they call "ex-innovators." This chapter provides new evidence on the extent to which the European system encourages the rise of new innovators, and the extent to which innovation in Europe is still the domain of established firms that diversify onto related technologies.

Chapters 5 and 6, by Stefano Breschi and Peter Swann, look at the relationships between innovative activity, geographical concentration and regional agglomeration. *Breschi* uses European patent data, along with information about the geographical localization of patent holders, and finds that in Europe spatial agglomeration is an important determinant of innovation because of the knowledge spillovers generated by geographical proximity. He also finds that the importance of spatial agglomeration differs across sectors and technological regimes. He ascribes these differences to differences in the nature of the underlying knowledge bases, in the related opportunity and appropriability conditions, and in the extent to which the benefits of technological knowledge depend on the cumulativeness of the learning processes. *Swann* asks what is the size of industrial clusters after which one observes an acceleration in their growth rates (take-off), and what is the size after which growth vanishes (peak level). Among other things he suggests that in large European countries (Germany, France, Britain, and Italy) many industrial clusters have already reached the peak-entry level, while the clusters in smaller countries (the Netherlands, Denmark, Belgium, Spain, Greece, Ireland, and Portugal) are probably too small to "take off." These are important conclusions which have significant implications for a European policy of industrial growth based on the potential that can be created from regional agglomerations.

The final two chapters in part II – chapters 7 and 8, by Nick von Tunzelmann, and Cristiano Antonelli and Marco Calderini – are related to some of the aspects dealt with in chapters 3–6, by focusing on two different industries: electronics and mechanical engineering. *Von Tunzelmann* looks again at the accumulation of firm competencies by analyzing the behavior of large European electronics companies. He discusses in detail the characteristics of the competence-accumulation process of these firms, their patterns of specialization and diversification, and the ensuing trends towards technological convergence among the different sub-fields of this industry. The analysis provides a comprehensive view of these firms, and discusses the related implications for competitive advantages. *Antonelli and Calderini* analyze the importance of localized technological change in skill-intensive industries such as mechanical engineering. Localized technological change is due to "bottom-up" processes based on generic as well as on

tacit knowledge, and on the improvements in design and production processes. The generation of innovation is thus mainly the outcome of the efforts of innovators that draw on learning processes highly specific to the history, context, and experience of innovators. Among other things, they use data on 136 Italian firms in the mechanical sector during 1988–93, and measure their "efficiency" by the error of a production function which relates the value-added of these firms to some of their tangible inputs. Using non-parametric estimation techniques, they show that the efficiency of these firms is highly correlated with demand shocks.

Part II is about inter-firm collaborations and research networks. It opens with chapter 9, by Patrick Llerena and Mireille Matt, which discusses policy aspects of inter-firm collaborations. *Llerena and Matt* contrast a "static" approach to the problem of inter-firm collaborations with a "dynamic" one. In a static approach, inter-firm collaborations tend to be viewed as a vehicle for collusion. As a result, the emphasis is on policies that restrict collaborative agreements because of the implied restraints on competition. But, as Llerena and Matt argue, collaborations should be examined primarily from a dynamic, evolutionary perspective. The emphasis should be on the implications for inter-firm learning and the exchange of complementary assets and capabilities. In short, a dynamic perspective underscores the beneficial effects of collaborations, and therefore calls for policy interventions that encourage agreements among firms endowed with complementary assets and capabilities.

While Llerena and Matt set the framework for analyzing inter-firm collaborations and research networks, chapters 10–12 look specifically at collaborative relationships among firms, with special emphasis on European collaborations in three main industries. *Antoine Bureth, Sandrine Wolff, and Antonello Zanfei* in chapter 10 examine an important feature of the dynamics of collaborations, and apply their framework to the case of the European electronics industry. They analyze whether, and to what extent, the stability of collaborations is influenced by the underlying characteristics and objectives of the partners. They discuss the tensions that arise in these collaborations, and the ensuing stabilizing and destabilizing forces. *Salvatore Torrisi* in chapter 11 looks at the software industry. He uses data on the growth and restructuring processes of 38 large US and European software firms during 1984–92. His main research hypothesis is that both internal and external growth operations (e.g. formation of new subsidiaries, or inter-firm agreements) reinforce firms' specialization rather than business diversification, and his empirical results find evidence that is consistent with this hypothesis. *Margaret Sharp and Jacqueline Senker* look at inter-firm collaborations in European biotechnology. They discuss in detail case studies of inter-firm agreements in this industry which offer a

comprehensive view of these relationships. Some of the agreements in their case studies are between large established pharmaceutical multinationals and newly formed biotechnology firms, while others are between more established biotech companies and large firms. Moreover, while some of the case studies are of US and European firms, others are intra-European collaborations. The case studies also highlight the factors that encourage and lead to successful relationships.

Chapters 13–15 deal specifically with research networks. These build on the theoretical framework of the so-called "new economics of science," advanced in particular by the work of Paul David. As we shall see below, this framework proves to be useful in analyzing an important dimension of research networks in Europe – the research networks created through research funding by the European Union and, more generally, the effects on the formation of these networks produced by the deliberate and systematic attempt by the European Union to enhance continent-wide R&D collaborations among firms and non-profit institutions (government research labs and universities).

Chapter 13, by *Paul David, Dominique Foray, and Edward Steinmueller*, offers a comprehensive survey of the approach underlying the new economics of science, its application to the formation and development of research networks, and related public policy implications. The chapter also opens some new issues in the agenda of the new economics of science, perfects others that were dealt with in other contributions, and suggests how this framework can be applied to understanding research networks and collaborations in Europe. Among other things, a relevant contribution of this chapter to the purpose of this volume is that it shows how the framework can be used to deal with the phenomenon of research networks among public and private institutions (and particularly of networks promoted by the European Union in the field of research and development of new technologies).

Following this line of analysis, chapter 14, by *Walter Garcia-Fontes and Aldo Geuna*, uses data on the BRITE-EURAM contracts from 1989 to 1993. Interestingly enough, this is one of the first times that a comprehensive data set of European research programs has been used to analyze a number of issues about the formation of research networks funded by the European Union. The interesting finding of the chapter is that it confirms the existence of a core set of institutions that participate repeatedly in many European-funded networks. However, the authors also find that these institutions have produced significant knowledge spillovers. The "hub" institutions typically link, in different networks, with different institutions (or firms) that do not participate repeatedly in them. The hub group then appears to be a vehicle for enhancing the participation of new partners in the European-funded networks.

Chapter 15, by *Aldo Geuna*, looks at the determinants of university participation in the R&D programs of the European Union. The chapter uses data on the number of participations of a fairly comprehensive sample of "higher-education" institutions. The sample was chosen independently of the participation in European programs, and includes institutions that did not participate in any of them. The interesting result of this analysis is that, after controlling for a number of factors (e.g. scale or the composition of scientific fields in the institution), scientific quality influences both whether a given institution participates or not in any program, and how many times it participates (i.e. the number of participations). As discussed in the chapter, this is suggestive of some sort of increasing returns in the participation in European R&D projects.

Some general conclusions

There are a few analytical conclusions that can be drawn from this collection of studies.

First, these studies confirm an important insight of recent work in the economics of innovation and related fields, such as organization theory and strategic management – that firms' competencies are characterized by *stability and inertia*. Competencies are hard to change, and companies tend to exploit systematically the special set of competencies that they have accumulated over time. Lock-ins and competence traps may thus take place, in that successful firms may be driven by their success in existing technologies to disregard new alternatives. Learning may then also contain the seeds for future failure.

Second, there is a considerable degree of *sectoral specificity* in the organization of innovative activities. This means, for instance, that one observes greater differences in learning patterns, entry rates, sources of innovation, and concentration of innovators across sectors in the same country than across countries for the same sectors. These invariances are the consequence of the type of knowledge base of innovative activities and the working of technological regimes which differ across sectors more than they differ across countries.

However, as some of these studies show, there are also important differences across countries and regions which can be ascribed to factors related to the specific characteristics of the *national and local systems of innovation*. Thus the role of institutions in various European countries seems to modify in different degrees the sectoral specificities of the organization of innovative activities. At the European level, this means that the forces promoting the convergence of the organization of innovative activities across countries due to technological regimes may be attenuated by the tendency towards diversity caused by historical or socio-cultural

differences, processes of division of labor or persistent differences in performance. As a consequence, tensions between sector specificity and national systems seem to play a relevant role in shaping the organization of innovative activity. The prevalence of one effect over another depends on the intensity of technological invariances, differences in the institutional settings and national systems of innovation, history and competitiveness of national companies, and degree of internationalization of R&D and production by companies.

One final set of insights produced by this collection is that the phenomena of *increasing returns* and *path-dependence* affect the nature of the innovation process and the dynamics of industries in Europe. There is a strong concentration of innovative activities in Europe; this emerges, for instance, from the analysis of the sectoral patterns of innovation and the geographical agglomeration processes in the continent. At the same time, the analyses of the European research networks in BRITE-EURAM and other programs, as well as the analysis of university participation in European R&D programs, provide empirical support to the idea that not only are these capabilities highly concentrated, but that this concentration may be reinforced by these programs. However, as discussed in the volume, there are offsetting factors as well, such as the fact that the hub institutions produce knowledge spillovers to other institutions.

Policy implications

What all these contributions suggest is that the balance between economic growth and European "cohesion" and integration is not an easy one to attain, and that considerable attention should be paid to finding policies that can effectively address the underlying trade-off. Although the book is not meant to provide policy prescriptions, some possible directions for further discussion of policy implications can be drawn from these studies.

Many of the studies suggest that innovation policy – or, more generally, industrial policy in Europe – has to take very seriously into account that the nature of technical change, and the related economic characteristics of the innovation process, display differences across industries that reflect differences in technological regimes. As a result, technology policy prescriptions cannot be formulated only general basis, but must also be made selective and sector-specific. They have to be based on the peculiar features of the different industries, with implied specificity in the instruments used and in prescriptions being made.

At the same time, the stability and inertia of firms' competencies create problems in the face of radical changes in technologies. Policy should in the first place try to reinforce existing competencies and specializations, and

rely on international trade and the international diffusion of knowledge for products, information, or knowledge where other continents or areas show greater comparative advantages. This is not to say that Europe should not stimulate dynamic competencies in order to change and move to new technologies: quite the opposite. Together with policies aiming at strengthening existing competencies, Europe should develop policies aiming at shifting from one key technology to another, in order to avoid being trapped in competence-destroying technical change. However this implies that Europe should also rely to a large extent on international trade, and particularly on the international flow of technologies and ideas. This in turn calls for a policy aimed at basic research and human-capital formation.

One should also keep in mind that drastic "jumps" in technological competencies can rarely produce immediate results. By reinforcing existing competencies and specializations one can gain complementary expertise at the international (both inter-continental, and intra-European) level, while encouraging at the same time some diversification of capabilities through gradual shifts into related knowledge fields. In this respect, a key issue for Europe is to encourage *innovative entry* by new firms in new technologies and sectors. New firms are important means for creating new capabilities at the industry level, as these firms do not bear the "sunk" costs related to existing technologies and products associated with large established companies.

Another set of policy implications concerns the role of *collaborations* and the formation of *research networks*. On these matters, one can only endorse the present policy of the European Union. By encouraging these alliances – or at least by pursuing policies that are not as stringent as the US anti-trust policy – Europe has given rise to a host of interactions and exchanges of complementary knowledge and assets among many firms, organizations and institutions. One can fairly say that this has been one of the most important achievements of the industrial (and social) policies of the European Union. Over the past 10–15 years, these policies have encouraged much more profound and systematic linkages among European economic agents in different countries than in the past, thereby enhancing tighter relationships among the diverse cultures and institutions of the various European nations and regions. This emphasis on European collaboration has created the conditions for cross-country interaction of many local European organizations that had previously rarely moved outside their boundaries, as well as the conditions for interactions of partners that were already "internationalized," but that (especially in science and technology) typically looked for partners outside Europe (particularly in the United States), in spite of the fact that some of the competencies or resources that were sought could be found in the continent as well. Clearly, this cannot be

the end of the story, and one still needs some considerable effort to enhance the participation of some European regions, especially in less advanced areas, in the continental networks.

Europe must be encouraged to insist on its underlying assumption that one must take a *dynamic* rather than a static perspective when assessing the social advantages of collaboration. Here the role of *diversity* among different European local or national systems of innovation may prove quite fruitful for effective collaboration, particularly if this diversity has generated complementarities in knowledge and competencies. The book also suggests that an important area where one needs deeper understanding of the policy implications of specific actions is the criteria on which to allocate resources for research. As noted in this book, the policy undertaken so far has maintained a sufficient degree of efficiency in the allocation process, while encouraging some diffusion of knowledge and technological information. Yet, one needs to dig more deeply into the specific mechanisms of these policies, and the underlying criteria for resource allocations, to examine their dynamic and long-run effects. One would like to know for instance whether concentration of research capabilities is actually being reinforced by these programs or not, in addition to what the studies in this volume have disclosed. The point is not that less concentration is socially desirable, but the implications of higher or lower concentration should be assessed more carefully. One should then evaluate more profoundly how one could resolve the trade-offs between short-run research efficiency, long-run innovation and growth, and long-run objectives of social cohesion.