

Innovation and Competitiveness of Nordic Services (ICONS)

Fulvio Castellacci, Patrik Karpaty, Keld Laursen and Patrik G. Tingvall



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Final Project Report

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Project page

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Abstract:

The ICONS project investigates the relationship between innovation and the international competitiveness of service industries. The various empirical studies produced within the project make use of a rich variety of data sources on the innovative activities and international performance of thousands enterprises in both manufacturing and service industries in the Nordic countries, and complement these with data at a more aggregate (industry- and country-) level of analysis. In order to shed new light on this engaging, broad and complex field of research, the project aims at three more specific (and interrelated) objectives: (1) the investigation of differences across industries in terms of their technological activities and economic dynamics, in order to highlight the main drivers of the process of structural change and industrial transformation in the long run; (2) the analysis of the link between innovation and economic performance at the firm-level, and of the extent to which this relationship is affected by sector-specific characteristics related to technological and market conditions specific to each industry; (3) the study of the patterns and determinants of different internationalisation channels and strategies that are undertaken by Nordic enterprises in the service sectors.

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1. Introduction

The main objective of the ICONS project is to investigate the relationship between innovation and the international competitiveness of service industries in the Nordic countries. This engaging topic is highly relevant for policy and has major implications in terms of economic welfare. Its investigation is however complex and presents some important conceptual and empirical challenges for research. The first is that most of the literature in this field has so far focused on manufacturing industries and neglected the service sectors, one major reason being the lack of data that has hampered empirical research on the subject until very recently.

The second challenge is related to the multifaceted and not unambiguous nature of concepts such as *innovation* and *international competitiveness*. This multifaceted conceptual nature implies an inherent difficulty in the empirical measurement of these concepts and in the analysis of the link between them. On the one hand, *innovation* is a complex and comprehensive construct that may take different forms in the different contexts in which it unfolds: service innovation, in particular, is characterized by some specific characteristics that differentiate it sharply from innovation in the manufacturing branch.

On the other hand, *international competitiveness* is also a multifaceted concept. A variety of factors shape the ability of an economic entity (firm, sector, country) to compete with its foreign counterpart, and technological capabilities and productivity dynamics have particularly attracted the attention of academic scholars as some of the major driving factors of competitiveness. However, the latter may in turn have important feedback effects on technological activities and the related productivity performance, since the process of international competition is admittedly one important factor enhancing the technological capability of economic actors. In short, when we think of the relationship between innovation and international competitiveness we are implicitly referring to a complex conceptual framework where the main variables of interest – innovation, productivity growth, internationalisation strategies and international performance – interact with each other and co-evolve over time in a complex manner.

The ICONS project acknowledges the complexity of the theme and takes it as the main starting point and major background motivating the research. In order to fulfil its primary objective – to shed new light on the relationship between innovation and international competitive-

ness in services – the project considers three principal themes and specific research questions.

The first part of the project investigates the relationship between innovation, structural change and economic performance at the aggregate (industry and country) level of analysis. The understanding of the channels through which innovative activities shape the dynamics of the economic system necessitates in fact an investigation of the long-run drivers of technological activities and economic performance of industries. This phase of the research does in particular develop a theoretical framework according to which the current process of industrial transformation and structural change characterized by an increasing importance of service activities may be explained as the outcome of the ongoing diffusion of the ICT-based general purpose technologies (GPTs), and the differential impacts that this diffusion process has on different types of manufacturing and service sectors. An aggregate (industry- and country-level) perspective is useful because it makes it possible to study the experience of Nordic service industries within a broader international framework and from a longer run perspective.

The second part of the project then shifts to a more detailed (micro) level of analysis by investigating the relationship between innovation and economic performance at the firm-level. Although the analysis of the innovation-productivity link has already received much attention in the scholarly literature, this part of the ICONS project intends to shed new light on the subject in one important respect, i.e. by emphasizing the importance of sector-specific conditions that characterize innovative activities in different industries (both technological and market conditions) and by studying how the industry-specific context affects the innovation and economic performance of enterprises. The empirical studies in this second work package make use of rich firm-level datasets comprising information on thousands of enterprises in all manufacturing and service industries in the Nordic countries.

The third phase of the project does also present a set of empirical studies based on a broad range of firm-level databases for the Nordic economies, but it shifts the focus to the analysis of the link between innovation and different internationalisation channels (e.g. exports, international collaborations, outsourcing). The underlying rationale is that technological activities are major drivers of the internationalisation strategies and international competitiveness of firms and that the latter, in turn, have an important feedback effect on the ability of enterprises to introduce new technologies and the amount of resources that they decide to invest in innovative activities.

Before introducing these three main themes in more details and discussing the results and implications of the papers presented within the ICONS project, the first task of this report will be to introduce the relevant literature in order to highlight some main research gaps in the field and indicate how the ICONS project has tried to overcome them (Castellacci, 2008a). This section first reviews the relevant bodies of literature on innovation and the competitiveness of manufacturing industries (sub-section 1.1), and then summarizes the literature of innovation and competitiveness in services (sub-section 1.2).

1.1 The literature on innovation and competitiveness in manufacturing

International competitiveness has for a long time been a relevant issue for policy and an engaging topic of academic research. It may be thought of as the ability of an industry to compete with its foreign counterparts. Behind the apparent simplicity of this definition, the concept of international competitiveness is indeed a complex one, and it is closely related to a number of different aspects (Cantwell, 2005). The ability of an industry to compete with foreign competitors does in fact refer to its trade performance and specialization patterns, as well as to the dynamics of its productivity. These aspects are closely intertwined. Productivity growth is an important factor to improve the terms of trade of an industry, and its trade performance, in turn, is a relevant engine of growth of value added and productivity.

Academic research on the subject has achieved great progress in the last two decades. Since the second half of the 1980s, the focus of economic research has shifted from the analysis of price- and cost-related factors of competitiveness to the important role played by technological change. The greater attention to technology and non-price factors of competitiveness corresponds to a shift of focus from short-run patterns to long-run dynamics, which has been greatly inspired by the classical contribution of Schumpeter (1934 and 1939) on the role of innovation and technology diffusion in the process of growth and structural change. Different strands of empirical research have recently flourished within the Schumpeterian tradition, providing new insights on the relationships between innovation and international competitiveness.

On the one hand, so-called new growth models have pointed to the existence of increasing returns and spillovers effects related to R&D activities, and have thus provided the theoretical foundation for the flourishing of a huge applied literature on R&D and intersectoral spillovers. On the other hand, a heterogeneous set of empirical studies within the evolutionary economics tradition have emphasized the sec-

tor-specific nature of innovation and extensively investigated its impact on the competitiveness of different systems of innovation. Despite having somewhat different research styles and approaches, these two Schumpeterian strands of research both indicate that, in a long-run perspective, the international competitiveness of industries is robustly related to two major factors, namely their own innovative activities and the intersectoral diffusion of advanced knowledge.

1.1.1 The mainstream economics view: R&D and knowledge spillovers

About two decades ago, the first contributions within the new growth theory tradition pointed out the important role of increasing returns for the growth process, and introduced this idea into a formal endogenous growth framework. The first models argued that investments in physical and human capital may generate externalities, increasing returns and, hence, persistent growth differences across countries (Romer, 1986; Lucas, 1988; Azariadis and Drazen, 1990). Subsequently, a second generation of models focused on the role of the R&D sector and the endogenous nature of the growth process. In the models of Romer (1990) and Aghion and Howitt (1992), the R&D sector produces new blueprints for the intermediate goods sector, and the expansion of the range of intermediate goods determines increasing returns and a scale effect on aggregate growth.

The idea that sectoral R&D and knowledge spillovers are important for growth and competitiveness originates therefore from these innovation-based new growth models. The main underlying assumption is that knowledge is a non-rival and (partly) non-excludable good, and that its public good characteristics lead to the existence of spillovers, increasing returns and endogenous growth.

These theoretical ideas raised new interesting questions for applied research. Do R&D and knowledge spillovers effectively lead to productivity growth, and how do industries differ in this respect? The empirical literature investigating the impact of R&D activities on sectoral differences in productivity growth is now huge. Typically, these contributions consist of econometric studies where the stock of (direct and indirect) R&D is included as a production factor together with capital and labour in an extended Cobb-Douglas specification. Thus, the growth of total factor productivity (TFP) in each sector is commonly regressed on its stock of sectoral R&D expenditures (measuring innovation) and on its indirect R&D stock (measuring R&D spillovers from other industries).

A large part of this literature focuses on this latter aspect, namely the indirect contribution that R&D expenditures in a sector have on the growth of productivity in other industries, so-called R&D spillovers (Griliches, 1992). From a conceptual point of view, it is possible to distinguish between two different types of spillover effects (Griliches, 1979). Rent spillovers are those where there is a pecuniary exchange between the provider and the recipient of technology, such as in the case of a supplier that sells an intermediate input to a user. Knowledge spillovers, on the other hand, do not entail any contractual agreement or pecuniary exchange between provider and recipient, and arise because of the public good nature of knowledge. It is therefore this second type of spillovers that more closely corresponds to the idea underlying new growth models. The major channels through which knowledge spillovers affect the growth of productivity are all related to innovating firms' R&D capabilities: reverse engineering, the mobility of R&D employees, their participation to technical meetings and scientific conferences, and the exploitation of codified information available in the form of scientific journals and patents (Levin et al., 1987).

The conceptual distinction between rent and knowledge spillovers is important, although it is frequently not possible to separate the two categories in empirical analyses. The strategy followed by most contributions in this field is to weight the stock of R&D of other sectors and to use it as a measure of intersectoral R&D spillovers. This is typically done in two ways. The first is to use transaction-based weights, such as inter-industry sales or investment flows, while the second is to construct measures of technological distance between industries. The former method closely corresponds to the concept of rent spillovers, whereas the latter implicitly focuses on knowledge spillovers.

The latter way to build up a measure of R&D spillovers has been followed by Jaffe (1986), who used as weights the distribution of patents across patent classes, and by Verspagen (1997a, 1997b), who used patent classifications and patent citations. These contributions, as well as several others in this field, have generally found evidence of a positive influence of R&D spillovers on sectoral productivity growth. Using a different methodology, based on a growth accounting type of sectoral decomposition of TFP, ten Raa and Wolff (2000) found a similar result, and showed the importance of technological spillovers from high-tech sectors (e.g. computers and electronics) for the growth of TFP of the whole economy.

A second strand of research in the R&D spillovers literature has extended the analysis to the investigation of the nature, extent and impacts of international knowledge spillovers. This empirical research is

inspired by a class of new growth models where sectoral R&D activities do not only sustain the dynamics of the domestic economy, but do also have positive effects for the competitiveness of foreign countries. In the models of Riviera-Batiz and Romer (1991) and Grossman and Helpman (1991), in particular, the R&D sector produces new blueprints that increase the variety of available intermediate inputs, and the latter positively affect the growth of foreign countries through cross-border trade and knowledge flows (representing channels of rent and knowledge spillovers respectively).

The major questions that these analytical models raise are therefore whether spillovers are really global, rather than national, in scope, and which the most effective channels of international diffusion are. Considering these issues, a set of recent empirical works have weighted R&D in other countries with imports, so to obtain a measure of foreign R&D acquired through imports of goods and services (see overview by Barba-Navaretti and Tarr, 2000). In particular, Coe and Helpman (1995), Coe et al. (1997) and Eaton and Kortum (1996) found that both domestic and international R&D spillovers have a positive effect on the growth of TFP at the aggregate level, and that the international diffusion of knowledge is a more relevant growth engine for small open economies than for large countries.

Verspagen (1997b), Dalum, Laursen and Verspagen (1999), Fagerberg and Verspagen (2000) and Keller (2000) performed a similar analysis at the sectoral level, and showed that both kinds of spillovers contribute to explain differences in productivity growth across industries. However, these works also pointed out that the relative importance of domestic vs. foreign R&D spillovers depends to a great extent on the econometric framework in which the analysis is undertaken. Foreign spillovers appear relatively more important when panel data are used, but much less relevant when the sample is cross-sectional in nature (Gittleman and Wolff, 1995).

The econometric literature on R&D spillovers, productivity and competitiveness represents a substantial and important body of research in this field. However, this literature raises one major question. Given that R&D activities constitute a major factor to sustain the international competitiveness of industries, what does, in turn, determine sectoral differences in R&D intensity? A large number of studies in industrial organization and, more recently, in the economics of innovation have in fact pointed out that R&D activities differ markedly across sectors, and that these differences may be explained as the outcome of the interplay of a complex set of sector-specific characteristics (e.g. Levin et al., 1987). Hence, the competitiveness of domestic sectors in foreign markets does not merely depend on their R&D in-

tensity but, first and foremost, on the structural characteristics that define the industry-specific opportunities, strategies and obstacles of innovative activities in different sectors. For instance, it has been shown that some low-tech and traditional industries do not innovate by undertaking formal R&D activities, but rather by acquiring advanced capital equipments from other sectors (Pavitt, 1984; Evangelista, 1999). In this case, the econometric strategy based on the estimation of R&D spillovers is likely to underestimate the innovative activities carried out by these sectors.

A different research tradition, rooted in evolutionary economics, emphasises the sectoral specificities of the innovative process, and it approaches the study of the international competitiveness of industries in a rather different way. To the discussion of this evolutionary literature we now turn.

1.1.2 The evolutionary view: technology-gaps, vertical linkages and innovation systems

The general proposition that innovation and intersectoral knowledge spillovers are important for the international competitiveness of manufacturing industries is a major point of agreement between new growth theories and evolutionary economics. The two approaches, however, differ substantially in terms of the conceptualization of the innovative process and the analysis of its economic impacts.

Evolutionary economics conceives innovation as a paradigm-bounded, sector-specific and context-dependent activity. The paradigmatic nature refers to the existence of dominant technological paradigms (or general purpose technologies, GPTs) that create, in any given historical era, a set of opportunities and constraints for innovative activities (Nelson and Winter, 1982; Dosi, 1982; Freeman et al., 1982).

Industries, however, “differ significantly in the extent to which they can exploit the prevailing general natural trajectories, and these differences influence the rise and fall of different industries and technologies” (Nelson and Winter, 1977: 59). Thus, the paradigmatic nature of technological knowledge does not only explain the relatively ordered patterns that may be observed in each phase of long run growth at the aggregate level (Dosi, 1988), but also the inherent tendency towards qualitative change and transformations at the sectoral level. This accounts for the industry-specific nature of innovation, which naturally leads, in turn, to give emphasis to the systemic context in which the innovative process unfolds. In the evolutionary view, the impact of innovation on the international competitiveness of industries must therefore be analysed within a complex framework comprising both,

the broader systemic context shaping innovative activities, and the sectoral specificities that characterize the creation and diffusion of knowledge.

In the last two decades, a large body of empirical research has developed within this tradition, and has extensively investigated the role of innovation for international competitiveness. This empirical literature is rich, and it has achieved considerable results. However, the different strands of research within evolutionary economics have not yet agreed on a standard set of models, methodology and stylized facts. This makes the task of summarizing this heterogeneous literature rather complex.

Figure 1 presents an attempt to organize this vast body of empirical research. The diagram reported in the figure represents the major strands of evolutionary applied research that have investigated the relationships between sectoral innovation and international competitiveness. Each arrow in the diagram corresponds to a branch of applied literature, and the variables on which this focuses. On the whole, figure 1 may therefore be considered as a stylized representation of a general evolutionary model, yet to be written, which is based on the co-evolution and the dynamic interactions between the systemic context, the creation of knowledge within sectors, the vertical linkages among industries, and their international competitiveness. This section clarifies the different parts of this evolutionary model by referring to the major strands of research and the main empirical results achieved by them. Four major aspects are relevant and will be discussed as follows.

Sectoral innovative activity

The technology-gap hypothesis argues that innovation is a major determinant of the competitiveness of industries in international markets. This idea was originally inspired by the seminal contribution of Posner (1961), and was subsequently investigated by a large number of empirical studies. These econometric works typically take the form of cross-section analyses of the relationship between measures of input and/or output of innovative activities (i.e. R&D and patents, respectively) and the trade performance of different industries. This set of studies has robustly pointed out that sectoral innovative activity is indeed a major determinant of international competitiveness, and that therefore, in a long run perspective, non-price factors are significantly more important than price related variables (Amable and Verspagen, 1995; Padoan, 1998; Montobbio, 2003).

A related strand of research within the technology-gap tradition focuses on the impacts of innovative activity on the dynamics of labour

productivity at the macroeconomic level. Macro-oriented studies of this type have consistently shown that cross-country differences in productivity and GDP per capita levels can be explained, among several other factors, by countries' abilities to innovate as well as their capability to exploit the international diffusion of technologies, so-called absorptive capacity (Abramovitz, 1986). These studies have shown that imitation, far from being an automatic and easy activity, is a costly process that requires an active effort to build up a strong social capability and an advanced industrial structure (Fagerberg, 1994).

This finding points out that sectoral innovative activity does not only have a direct positive effect on international competitiveness through its impact on trade performance, but an indirect effect as well, since the upgrading of a country's industrial structure increases its absorptive capacity and, hence, its ability to imitate foreign advanced technologies (Fagerberg and Verspagen, 2002). The two aspects, sectoral innovative activity and international diffusion of new technologies, are therefore closely related to each other, and both of them are important to sustain the competitiveness of national industries in the international arena.

Vertical linkages and intersectoral knowledge flows

A related strand of research within the evolutionary tradition investigates the so-called home market hypothesis. This was originally put forward by Linder (1961), and later developed by Porter (1990) and Lundvall (1992). The idea is that the home market constitutes a fundamental arena to develop, test and commercialise new products in the early phase of their introduction, before they are eventually exploited in foreign markets. The characteristics of the home market, and particularly the vertical linkages between suppliers, producers and users of advanced technologies, represent therefore a major factor of competitive advantage.

The focus on the importance of vertical linkages is intrinsically related to the sector-specific nature of innovation. A large set of evolutionary studies has in fact shown that innovative activities, strategies and performance greatly differ among manufacturing industries, and that different sectors tend to follow very distinct technological trajectories over time (Nelson and Winter, 1977; Malerba, 2005). Pavitt (1984), in particular, put forward a well-known taxonomy that identifies four sectoral trajectories, i.e. four groups of industries characterized by markedly different innovative modes, namely science-based, scale intensive, specialised suppliers and supplier dominated industries. The most original feature of Pavitt's taxonomy is its focus on the intersectoral exchange of advanced knowledge that continuously flows among the various industry groups, so that each of them assumes a well-

distinct and specific function in the system of innovation as a provider and/or recipient of technology to/from the other groups of sectors.

Inspired by these insights on the importance of the home market and its vertical linkages, a recent strand of empirical research has investigated their relevance to explain the international competitiveness of different industries. These econometric studies have considered, in addition to variables typical of the technology-gap approach, the role of intersectoral knowledge flows to explain the dynamics of export market shares and specialization patterns, and have shown, in particular, the importance of user-producer interactions and of upstream linkages between suppliers and producers (Fagerberg, 1995; Fagerberg and Verspagen, 2000; Laursen and Meliciani, 2002). Furthermore, using Pavitt's taxonomy as a framework, the home market hypothesis literature has shown that vertical linkages are not equally supportive of foreign competitiveness for all different groups of manufacturing industries. Upstream linkages, in fact, are more important factors for scale intensive sectors, downstream linkages are more relevant to shape the competitive position of specialised suppliers, whereas University-industry links constitute a more crucial factor for science-based industries (Laursen and Drejer, 1999; Laursen and Meliciani, 2000).

Technological regimes

The strands of applied literature presented above raise one major question. Given that sectoral innovative activity and intersectoral knowledge flows are important factors to sustain the international competitiveness of manufacturing industries, what does in turn determine them? In the investigation of the sector-specific characteristics of the innovative process, the focus of evolutionary studies is on the nature of learning processes, which are specific to a given technological environment. A technological regime (Nelson and Winter, 1982; Winter, 1984) defines such a technological environment, i.e. the framework conditions in which firms' innovative activities take place. In each sector of the economy, some technological characteristics affect the direction and intensity of learning processes and the knowledge accumulation by economic agents.

Extending previous empirical works in industrial organization (Cohen and Levin, 1989), recent evolutionary studies have focused on four main characteristics of sectoral technological regimes: (i) the nature of the knowledge base, i.e. the "properties of the knowledge upon which firms' innovative activities are based" (Breschi and Malerba, 1997, p.136); (ii) the appropriability conditions, i.e. the possibilities of appropriating the innovative rents by protecting innovations from imitation through a variety of means, such as patents, process secrecy and

know-how, design and R&D know-how, and other non-technical means; (iii) the cumulateness conditions, which define the extent to which current innovative activity builds upon the experience and results obtained in the past; (iv) the technological opportunities, i.e. the “likelihood of innovating for any given amount of money invested in search” (Malerba, 2005). This definition focuses on the level of technological opportunities, that is on the relationships between input and output of the innovative process in different sectors of the economy. However, besides the level of opportunity, there are other important aspects that contribute to shape sectoral technological opportunities, such as its variety, pervasiveness and sources. The exploitation of technological opportunities is thus a complex and multifaceted process, and it is strictly linked to the existence of major dominant technological trajectories in different industries of the economy (Marsili, 2001; Marsili and Verspagen, 2002).

The investigation of the nature of technological regimes has recently led to a surge of applied research in evolutionary economics. In particular, it has been shown that the characteristics of technological regimes may shed new light on two relevant aspects of the innovative process. First, they may explain the existence of different patterns of market structure and industrial dynamics in different sectors of the economy. Most of the recent works in this field (Malerba and Orsenigo, 1995 and 1996; Breschi and Malerba, 1997; Breschi et al., 2000) have focused on sectoral differences in terms of concentration of innovative activity, size of innovative firms, ease of entry in the market, turbulence or stability in the population of innovative firms. These studies have argued that sector-specific technological regimes may explain the existence of the two main patterns of innovation originally pointed out by Schumpeter (1934 and 1943). The first, the Schumpeter Mark I, is characterized by high ease of entry in the market, low concentration of innovative activity, and a turbulent population of new and old innovators with a significant role played by small firms. Creative destruction (Schumpeter, 1934) is the main feature of this regime (also defined ‘entrepreneurial’ or ‘widening’). The second, the Schumpeter Mark II pattern, is characterized by high barriers to entry for new innovators, high concentration of innovative activity, and a stable population mainly formed by large and well-established firms. Creative accumulation (Schumpeter, 1943) is the distinctive feature of such a regime, also defined ‘routinized’ or ‘deepening’.

Secondly, a more recent branch of research has focused on the impact that sectoral technological regimes have on the international competitiveness of industries. Malerba and Orsenigo (1995 and 1996) and Malerba and Montobbio (2003) show that technological opportunities, properties of the knowledge base, appropriability and cumulateness

conditions are relevant factors to explain the patterns of international technological performance, measured by the 'revealed technological advantage' in terms of patents. Relatedly, the characteristics of technological regimes have also been shown to have an impact in terms of export market share dynamics. Based on the estimation of a technology-gap trade model, other econometric studies have in fact found that sectoral trade performance is closely related to a range of industry-specific technological variables, such as technological opportunities (Laursen, 1999), cumulateness (Lee and Lim, 2001) and appropriability conditions. In a nutshell, these studies provide an extension and a refinement of the technology-gap approach, as they shed new light on the links between the structural characteristics of sectoral systems of innovation, on the one hand, and their competitiveness in international markets, on the other.

The co-evolution of national and sectoral systems

Evolutionary economics emphasizes the context-specific nature of innovative activities. In the study of sectoral patterns and impacts of innovation, the context that it is relevant to look at does not simply refer to the structural characteristics defining the industry-specific technological regime, but also the broader systemic context within which the innovative process unfolds. Sectoral innovation is greatly shaped by the characteristics of the national system of innovation, and the latter, in turn, is affected by the former. The co-evolution of national and sectoral systems is therefore a major factor to drive international competitiveness.

The idea that sectoral and national systems are intertwined has been recently put forward by Mowery and Nelson (1999) Murmann and Homburg (2001), Malerba (2005) and Castellacci (2006). These studies have pointed out the existence of three channels of interactions between sectoral patterns and national systems.

The first refers to the performance of national systems. The technology-gap and home market hypotheses discussed above point out that sectoral innovative activities and intersectoral knowledge flows contribute to shape the specialization patterns, productivity dynamics and trade performance of the whole system of innovation. Several empirical studies, in addition, indicate that the specialization profile matters for macroeconomic performance, and that countries that are able to shift their industrial structure towards areas characterized by higher technological opportunities experience a more dynamic aggregate performance in the long run (Carree, 2003; Peneder, 2003). In turn, the country-specific patterns of scientific, technological and economic specialisation, together with the other features characterizing the home market, affect, strengthen and reproduce over time the innovative ac-

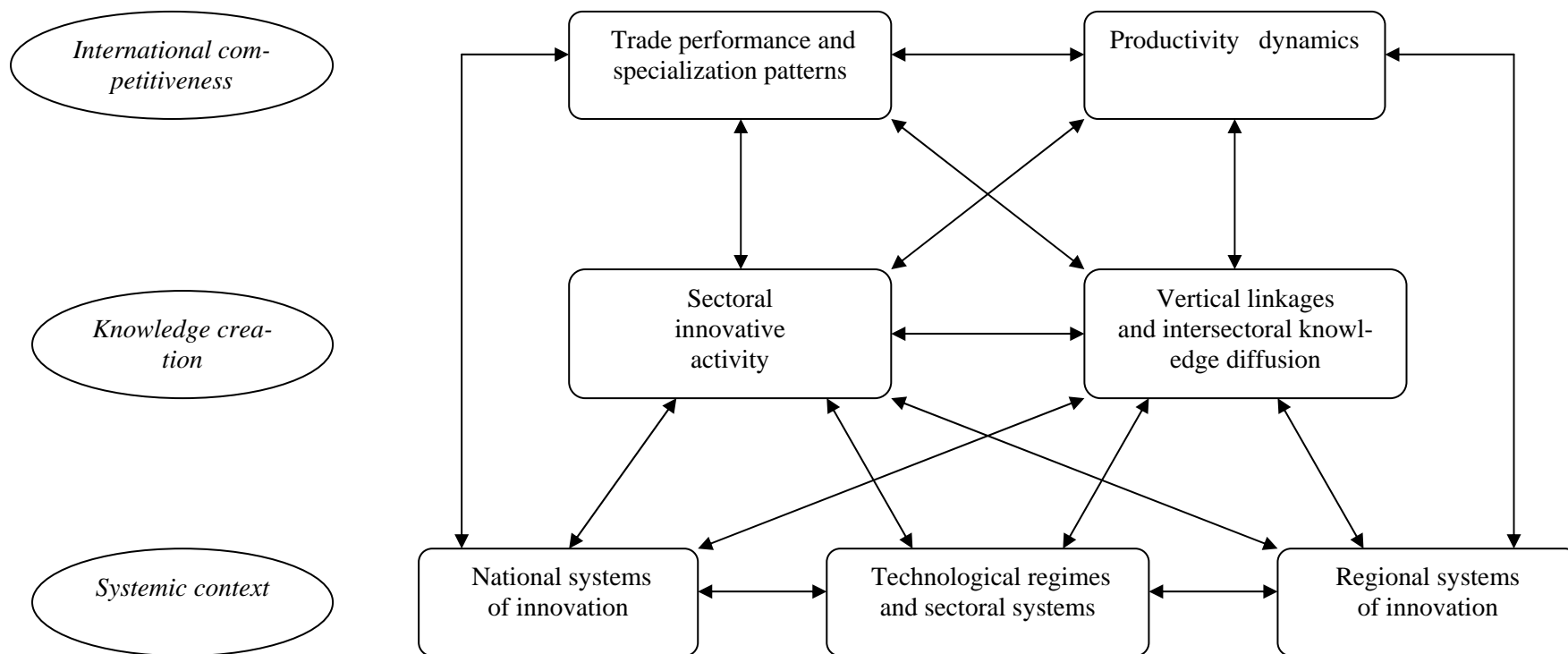
tivities of the domestic producers and the intersectoral linkages between producers, suppliers, users and the science system (Porter, 1990; Lundvall, 1992; Mowery and Nelson, 1999). Various empirical studies have in fact shown the continuity and persistence of country- and sector-specific technological trajectories and specialisation patterns over long periods of time (Cefis and Orsenigo, 2001; Fai and Von Tunzelmann, 2001; Laursen and Salter, 2005).

Secondly, the policy level constitutes a major channel of interaction between the meso and the macro level. In fact, the existence of important industries or core industrial areas where the country is specialised, with the related set of well-established vertical linkages that they entail, may shape regulations and governmental decisions at the national level, and affect in particular (i) innovation policies, (ii) industrial policies, (iii) IPRs regulations, and (iv) University-industry links (Mowery and Nelson, 1999). If national policies actively promote core industrial areas for a prolonged period of time, and neglect others, this policy strategy will affect the entire national system of innovation, which may eventually turn out to be locked in into a specific path (Narula, 2002). Conversely, national policies may directly affect sectoral innovative activities, cooperation patterns, intersectoral linkages and University-industry collaborations through a wide variety of incentives, schemes and regulations (Lundvall and Borrás, 2005; Mowery and Sampat, 2005).

Thirdly, a broad range of other country-specific factors, of a social, institutional, and cultural nature, affect, as well as are shaped by, the degree of trust and cooperation in the system and, relatedly, the intensity of intersectoral linkages and the exchange of advanced knowledge. Network interactions and systemic relationships are in fact embedded in, and co-evolve with, a complex set of social and cultural factors that are specific to a given national framework (Powell and Grodal, 2005).

In short, the co-evolution between sectoral patterns and national systems of innovation tends to strengthen and reproduce a given country- and industry-specific technological trajectory over time. Sectoral innovative activities and vertical linkages, due to their persistent, enduring and context-dependent nature, are fundamental for explaining the cumulative and path-dependent dynamics that innovation systems follow over time and their patterns of international competitiveness.

Figure 1: Innovation and the international competitiveness of industries (source: Castellacci, 2008a)



1.2 The literature on innovation and competitiveness in services

One striking feature of the vast empirical literature discussed in this section is that it is mostly focused on the international competitiveness of manufacturing industries, and has so far largely neglected the service sectors. The lack of empirical analyses on innovation and the international performance of services constitutes an important research gap in this field, given that service industries account by now for a large share of value added, employment and trade in most industrialized countries.

Different explanations have been put forward to explain the steady increase that services have experienced in recent decades. The first is the well-known *cost-disease* argument originally proposed by Baumol (1967), according to which the service sectors tend to increase their employment share due to their lower productivity levels and sluggish dynamics as compared to manufacturing. This traditional view of services as productivity laggards and employment sponges, though, has more recently been called into question by the great dynamism that some advanced service sectors have shown in connection to the emergence and diffusion of ICTs. Different theoretical explanations have therefore been put forward to explain the process of structural change and the rapid shift of economic activities from manufacturing to services. One focuses on the greater income elasticity of the consumption of services *vis-a-vis* manufacturing goods. The greater income elasticity implies that, as industrialized economies increase their levels of GDP per capita, a higher proportion of the latter is spent for the consumption of services (Gregory et al., 2006).

Another explanation, not in competition with the former, emphasizes the fact that an intense process of outsourcing has taken place in recent decades, where many activities previously performed within manufacturing firms are now carried out by specialized business services. This pattern of outsourcing leads to a twofold interpretation. On the one hand, it suggests that (at least part of) the shift from manufacturing to services that we observe in national accounts and statistics may be accounted for by a re-allocation of existing activities, rather than by a real process of structural change and creation of entirely new services. On the other hand, however, several works point out that outsourcing is inherently related to the increasing complexity of the knowledge-based productive process, and that it therefore constitutes one major aspect of the greater technological and economic specialization that characterizes modern production (Fixler and Siegel, 1999). Thus, far from being a mere statistical artefact, outsourcing reflects an intense process of structural change and a radical reorganization of the division of labour among technologically advanced sectors. What this

process is leading to is an increasing interdependence and a more intense knowledge exchange between manufacturing and service activities (Franke and Kalmbach, 2005). Innovation lies at the very core of this process of structural change and intensification of inter-sectoral linkages.

1.2.1 Innovation in services

Innovation studies have traditionally focused on manufacturing industries and, until recently, neglected the service sectors. In the last few years, however, an emerging body of literature has pointed to the increasingly important role of innovation for the creation of entirely new ICT-based services as well as for the growth of existing ones. The literature on innovation in services represents by now one of the most rapidly growing areas within innovation studies (Drejer, 2004; Miles, 2005). Studies of service innovation emphasize the peculiarities of the innovative process in services as compared to manufacturing industries, and argue that these sectoral specificities require a set of new concepts and approaches to study innovative activities and patterns in this increasingly dynamic branch of the economy. Service innovation, in particular, is characterized by four important peculiarities that make it sharply different from innovation in manufacturing.

First, the provision of services is characterized by the *co-terminality* between production and consumption (Hill, 1999). This means that the provision of a service cannot be spatially and temporally disentangled from its consumption, i.e. the service must be consumed at the same time and in the same place as it is produced. This implies that the distinction between product and process innovation, an important conceptual pillar of studies of innovation in manufacturing, cannot easily be applied in the context of the service sectors.

Secondly, the intangible and information-based characteristics of services inherently give a predominant role to *the use and production of ICTs* (Evangelista, 2000). The emergence of the ICT-based technological paradigm (or GPT), in fact, is closely associated with the creation of new advanced service activities, and the co-evolution between the latter and the diffusion of the ICT-based general purpose technologies constitutes a major source of structural change in the knowledge-based economy.

Thirdly, the close relationship between service providers and consumers and the great flexibility of services associated with ICTs lead to an intense process of *customisation* and to a great relevance of *interactivity* (Miles, 2005). User-producer interactions are certainly important in several technologically advanced manufacturing activities, but assume

an even more important role to shape innovative activities in services. Relatedly, as a consequence of their intangible nature and of the close proximity between users and producers, service innovations are frequently difficult to appropriate, at least through conventional means such as patenting.

Fourthly, human resources and the skills of the firms' employees are very important strategic assets for innovative activities in services, because the latter are predominantly based on the creation and diffusion of advanced knowledge in intangible activities, rather than on the accumulation of physical capital and tangible assets (Gallouj and Weinstein, 1997). Innovative strategies must take this into great account, and this implies, in particular, that training activities and organisational changes become central aspects of the innovative process, while formalised R&D activities are relatively less important than in manufacturing industries. This also suggests that the traditional approach to the study of innovation and competitiveness, based on the concept of R&D spillovers (see literature review in the previous section), cannot easily be applied within the context of the service sectors, precisely due to the different modes of innovation and the minor relevance of R&D activities that characterize the latter.

Besides pointing out these major aspects of service innovation, this recent literature emphasizes the existence of a great variety of innovative strategies and patterns within services (Evangelista, 2000; Tether, 2003). The service branch of the economy consists in fact of a very heterogeneous set of activities, and the study of innovation in different service industries must take these sectoral specificities into great account. Thus, similarly to what previously done for the study of manufacturing industries, innovation scholars have recently started to propose taxonomies of service innovation with the purpose of identifying some major sectoral patterns of innovation, or technological trajectories, that characterize different groups of service industries.

In the economics literature, a traditional and well-known distinction is the one between *producer*, *distributive* and *personal* services (Park and Chan, 1989). This simple taxonomy is not explicitly focused on innovation, but it is important because it points out the different function that various groups of service sectors perform within the economic system, i.e. as providers of intermediate, distributive or final services respectively. Building upon this original distinction, but emphasizing the role of innovation and of intersectoral exchanges of knowledge among different groups of industries, Miozzo and Soete (2001) have more recently proposed an interesting taxonomy of sectoral patterns of innovation in services. This taxonomy is inspired by Pavitt's (1984) conceptualization, and it uses a similar approach to

examine the innovative patterns of different types of service industries.

Supplier dominated services, similarly to the corresponding category of Pavitt's taxonomy, predominantly innovate by acquiring advanced capital equipments from manufacturing sectors. These industries represent the least technologically advanced branch of the economy (e.g. restaurants and hotels, laundry, repair, barber and beauty), roughly corresponding to the traditional view of services as productivity laggards, and they provide a heterogenous set of personal services that are purchased by final consumers.

Scale intensive infrastructural services constitute the physical and the information network infrastructure of the knowledge-based economy. These industries innovate mainly by acquiring advanced capital equipments from manufacturing industries (e.g. ICTs), which lead to efficiency and quality improvements of the infrastructural and distributive services they provide to the whole economic system. Physical networks are constituted by industries such as transport, travel, trade and distribution; while information networks characterize sectors heavily dependent on the use of ICTs, and in particular finance, insurance and communications.

The third category of Miozzo and Soete's taxonomy refers to the most technologically advanced and dynamic branch of the modern economy, so-called *knowledge intensive business services (KIBS)*, which correspond to Pavitt's science-based and specialised suppliers sectoral trajectories. These industries innovate by interacting closely with advanced manufacturing sectors, and their knowledge base is complex and strictly related to the production of scientific knowledge by the S&T system. Their major function in the system of innovation is to produce specialized knowledge and perform problem-solving activities for manufacturing and other service sectors, thus assuming a major role for the creation and intersectoral diffusion of advanced knowledge (e.g. R&D, software and other ICT-related services, engineering, consultancy).

1.2.2 Innovation and economic performance in services

While research on sectoral patterns of innovation in services has recently experienced rapid advances, the investigation of the economic performance of service innovation has been much more limited in scope, arguably due to some methodological and conceptual difficulties that will be briefly discussed in this section. The economic performance of service innovation is investigated by two related groups

of studies, one focusing on the dynamics of productivity and the other on international trade in services.

The study of the relationships between innovation, and particularly ICTs, and productivity growth in manufacturing has recently received much attention in innovation studies, but the corresponding analysis for the service sectors has been rather limited (Heshmati, 2003). The diffusion of the ICT-based general purpose technology has led to the optimistic expectation of a pervasive effect of innovation on the growth of productivity in many sectors of the economy, and particularly in services, due to their intangible nature and the great use that these make of ICTs. Some applied studies have investigated this general hypothesis by making use of firm-level data for selected countries, e.g. Mairesse and Kremp (1993), Lichtenberg (1995), Licht and Moch (1999) and Cainelli et al. (2006). Others have used industry-level data or input-output tables to compare productivity levels in services across countries (e.g. Van Ark et al., 1999).

The results from these studies are mixed and not yet conclusive. ICTs and innovative activities appear to have led to rapid productivity growth of service industries in the last decade, but such a positive impact is not always found when the data refer to previous periods. One possible factor accounting for this may be related to the slow pace of adoption of ICTs, particularly in European countries (Dalum et al., 1999). Another explanation, though, points to the methodological difficulties that this type of empirical studies entails. In fact, while the measurement of inputs does not present particular problems, the measurement of output of service activities is more complex than it is the case for manufacturing goods. Service output is hard to measure due to the heterogenous nature of services, the intense process of customisation and the great flexibility to users' needs, and the related difficulty to measure quality changes by using standard definitions (Griliches, 1994; Van Ark et al., 1999). Consequently, conventional ways to measure productivity may fail to catch the rapid process of quality and efficiency change that ICTs lead to in services, and a range of different methods have therefore been recently proposed (for an overview, see Heshmati, 2003).

The study of the impact of innovation on the dynamics of productivity in services has important implications for understanding their patterns of international competitiveness. A related strand of research focuses more directly on the international economic performance of service industries in terms of trade and specialization patterns. This has in recent decades become a very relevant issue. International trade in services account now for more than 30% of total trade, and around 60% of FDI in the OECD area are directed towards service activities

(Grünfeld and Moxnes, 2003). The emergence of new competitors in some rapidly developing economies contributes to make global competition for service market shares tougher. Service providers in some of these emerging markets, particularly in Asia (e.g. India), are now able to produce technologically advanced services at low costs, thus constituting a possible threat for other firms worldwide. At the same time, emerging markets do also open up new opportunities for the export of services produced by industrialized countries.

In the international economics literature, several analytical models have been proposed to study the trade patterns of the service sectors, and in particular of producer services. Most of these models have inserted producer services within a Heckscher-Ohlin framework, and have shown the advantages and welfare gains that liberalization and free trade of service activities may lead to (e.g. Markusen, 1989; Melvin, 1989; Van Marrewijk et al., 1997). This type of analytical models also have an important policy dimension. The debate on the “trade-in-services” is currently vivid, and the liberalization of services that the GATS agreement seeks to promote may have important economic consequences worldwide (Hoeckman and Primo Braga, 1997). This debate and the related modelling exercises, though, have almost exclusively focused on the effects of institutional reforms (e.g. liberalization) and related price factors for the international exchange of services through trade and FDI, while the role of innovation has not been considered to the same extent.

Why have the service sectors been neglected by most previous studies of innovation and international competitiveness? We point out two main reasons for this. The first has to do with the lack of relevant data. Until recently, data on innovative activities and international performance in services were scarce and often not comparable across countries. However, the last decade has seen the emergence and rapid diffusion of new data sources such as, among others, the Community Innovation Survey and the OECD database on International Trade in Services. In addition, the rapid diffusion and greater use of new firm-level datasets now provide a great variety of information on innovation and the economic performance of large samples of manufacturing and service enterprises.

The second reason refers to some important conceptual issues. The study of the international competitiveness of services is quite complex, due to the specific characteristics of service activities and to the great differences with the patterns prevailing in manufacturing industries. As discussed above, the provision of services is characterised by important peculiarities, such as the co-terminality between production and consumption, the importance of customisation and user-producer

interactions, and the relevance of organisational factors and non-technological types of knowledge (Drejer, 2004; Miles, 2005). These characteristics frequently require a close proximity between service providers and consumers, and thus tend to hamper the international exchange of services through trade. This has led to the common, though not entirely correct, perception that 'services are non tradable'.

However, in recent decades, information and communication technologies have in many cases overcome the co-terminality of production and consumption of services, mainly through two interrelated channels. First, innovations in ICT-related advanced services (e.g. software, telecommunications) have created a digital network infrastructure that has significantly increased the scope for the internationalisation and tradability of services (Hoeckman and Primo Braga, 1997; Miozzo and Soete, 2001; Freund and Weinhold, 2002). Secondly, the creation of new advanced services and the quality improvements of existing ones have led to the emergence of new opportunities for the international exploitation of these in foreign markets.

Thus, though recognising that some methodological and conceptual difficulties exist, it is important to emphasize that these may to a large extent be overcome. The lack of previous studies on the relationships between innovation and international trade in services does therefore constitute a limitation of current research and an important area of investigation for the future. The number of previous studies on this topic is very scant, but a few recent empirical works do indeed suggest that innovation is a key dimension to understand the determinants of international competitiveness in services (Windrum and Tomlinson, 1999; Freund and Weinhold, 2002; Di Cagno and Meliciani, 2005; Guerrieri and Meliciani, 2005). The most significant aspect that these recent works indicate is that, in order to understand the role of innovation for the international performance of services, it is necessary to look at one crucial factor, namely the intensity and the direction of inter-sectoral linkages and exchanges of advanced knowledge between different groups of service and manufacturing activities.

2. The themes of the project: studies, results and implications

As previously outlined, the overall objective of the ICONS project – the study of the relationships between innovation and the international competitiveness of Nordic services – relates to a broad and complex field of research. The project has tried to shed new light on this engaging and multifaceted theme by focusing on three more specific topics within this area. These topics are of course closely related to each other and represent different sides of the overall theme. Within the framework of the ICONS project, it has however been convenient to organize the research work by investigating them in three separate, though interrelated, research components.

The first part of the project investigates the relationship between innovation, structural change and economic performance at the aggregate (industry and country) level of analysis. The understanding of the channels through which innovative activities shape the dynamics of the economic system necessitates in fact an investigation of the long-run drivers of technological activities and economic performance of industries. This phase of the research has in particular developed a theoretical framework according to which the current process of industrial transformation and structural change characterized by an increasing importance of service activities may be explained as the outcome of the ongoing diffusion of the ICT-based general purpose technologies (GPTs), and its differential impacts on different types of manufacturing and service sectors. An aggregate (industry-level) perspective is useful because it makes it possible to study the experience of Nordic service industries within a broader international framework and from a longer run perspective.

The second part of the project has then shifted to a more detailed (micro) level of analysis by investigating the relationship between innovation and economic performance at the firm-level. Although the analysis of the innovation-productivity link has already received much attention in the scholarly literature, this part of the ICONS project has tried to shed new light on the subject in one important respect, i.e. by emphasizing the importance of sector-specific conditions that characterize innovative activities in different industries (both technological and market conditions) and by studying how the industry-specific context affects the innovation and economic performance of enterprises. The empirical studies in this second work package make use of rich

firm-level datasets referring to thousands of enterprises in all manufacturing and service industries in the Nordic countries.

The third phase of the project does also present a set of empirical studies based on a broad range of firm-level databases for the Nordic economies, but with a shift of focus to the analysis of the link between innovation and different internationalisation channels (e.g. exports, international collaborations, outsourcing). The underlying rationale is that technological activities are major drivers of the internationalisation strategies and international competitiveness of firms and that the latter, in turn, have an important feedback effect on the ability of enterprises to introduce new technologies and on the amount of resources that they decide to invest in innovative activities.

The next three sub-sections describe in some details these three phases of the project by reporting the main motivation, results and implications of the various papers produced for each work package of the ICONS project.

2.1 Part 1 – Industry-level studies: manufacturing and service industries in a new taxonomy of sectoral patterns of innovation

As pointed out in section 1.2, the service innovation literature has increasingly attracted the attention of innovation scholars in the last few years and it has achieved considerable progress in the understanding of the factors that shape innovative activities and results of firms in the service industries. However, the service innovation literature seems to be developing into a separate field of investigation within innovation studies, without much interaction with or relation to the well-established paradigm-regime-trajectory model already developed for the study of innovation in manufacturing industries (and briefly reviewed in section 1.1). One major challenge ahead in the field is therefore to provide a more integrated view of the characteristics that innovation takes in manufacturing *and* in service industries alike, and to shed new light on the relationships between these interrelated parts of the economy.

Motivated by this need for greater integration between the study of manufacturing and service innovation, this first phase of the project presents two industry-level studies whose main objective is to present a new sectoral taxonomy that combines manufacturing and service industries within the same overall framework, and to empirically analyse its characteristics and properties. As previously outlined, the type of analysis undertaken here has a rather aggregate focus, i.e. it focuses on the industry-level of analysis. This is important because, due to the

greater availability of industry-level data for a longer time period and a large sample of countries, this phase of the research is explicitly comparative in nature and makes it possible to analyse the Nordic experience in an international and long-run perspective.

The first of these studies is presented by Castellacci (2008b), who puts forward a new taxonomy of sectoral patterns of innovation and discusses its theoretical foundations and main properties. The sectoral taxonomy combines elements of sectoral classifications previously pointed out in the economics and innovation studies literatures.

On the one hand, the economics literature has frequently adopted a product-related type of classification, where industrial sectors are identified according to the kind of item that firms predominantly produce and commercialise. The product-related classification naturally leads to an emphasis on the function that each industry assumes in the economic system as provider (recipient) of goods and services to (from) other industries, i.e. its stage in the vertical chain. One well-known example of this type of *product- and function-related classification scheme* can be seen in the “new growth” literature. New growth models admittedly provide a rather stylized representation of sectoral groups, which mainly differ in terms of their function in the economic system as producers of blueprints (the R&D sector), intermediate or final goods (see e.g. Romer, 1990; Grossman and Helpman, 1991). This standard type of three-sector model presents a useful stylized representation of the economy, but it does not enable detailed investigation of the industry-specific nature of innovation and the great variety of sectoral patterns of technological change characteristic of the knowledge-based economy. While recognizing the analytical appeal of this simple type of classification, the new typology presented in this phase of the project aims to provide a more precise characterization of sectoral patterns of innovation than what is commonly offered by endogenous growth models in the economics literature.

On the other hand, the innovation studies literature has frequently adopted sectoral classifications that point out more explicitly the characteristics of the process of technological change, rather than the types of items produced by firms in various sectors. *Technological systems of classification* focus on the innovative modes and strategies that are adopted by firms in different parts of the economic system, i.e. the characteristics of their technological regimes and trajectories. As pointed out in section 1.1, the focus on technological regimes and trajectories naturally leads to an emphasis on the vertical linkages and knowledge exchanges that firms in different sectors of the economy have with their suppliers and/or with the users of new technologies. A familiar example of this type of classification scheme is the taxonomy

of Pavitt (1984), where the main focus is on the innovative mode adopted by different sectoral groups and the related inter-sectoral knowledge flows. The new taxonomic model also builds upon this type of classification scheme, but it differs from previous sectoral taxonomies in the innovation studies literature in one important aspect. While typologies of manufacturing and service innovation have so far been carried out separately and independently of each other, the taxonomic model proposed here combines manufacturing and services within the same framework, and points out the fundamental role played by vertical linkages and inter-sectoral knowledge exchanges between them.

Figure 1 presents a stylized representation of this taxonomic model. In an attempt to consider product- and technology-related characteristics simultaneously, the typology is constructed by dividing industrial sectors along two main dimensions. The first focuses, in analogy with the endogenous growth literature, on the *function* assumed by each industry in the economic system as provider and/or recipient of goods and services, i.e. its position in the vertical chain. Industries that provide final (intermediate) goods and services to other sectors are therefore positioned at a higher (lower) level on the Y-axis in the diagram in figure 1.

The second dimension represents, in analogy with previous taxonomic exercises in the innovation literature, the *technological content* of an industry, i.e. the overall level of technological capabilities of innovative firms in the sectoral system. This dimension is thus defined by the technological regimes and trajectories that characterize sectoral systems, and the extent to which industrial sectors are able to create new technologies internally or must rely on the external acquisition of machinery, equipment and knowledge from their suppliers. Technologically advanced sectors, able to develop new technologies internally and provide them to the rest of the economy, are positioned on the right-hand side of the X-axis in figure 1, whereas industries that mostly acquire advanced knowledge from other sectors rather than creating them internally are positioned on the left-hand side of the X-axis.¹

¹ One important caveat needs to be noted. The two dimensions pointed out here and graphically presented in figure 1 admittedly provide a rather stylized and simplified representation of concepts that are indeed multi-dimensional in nature. First, the vertical chain represented on the Y-axis of figure 1 refers to the product chain, and the related set of input-output sectoral exchanges. The chain would, however, look different if structured in terms of, e.g., knowledge or financial flows. Furthermore, the degree of vertical integration in the industrial system changes over time, so that different sectors, and firms within sectors, may indeed shift their relative position on the vertical chain in the long run (Von Tunzelmann and Acha, 2005). Secondly, the technological content dimension represented on the X-axis in the figure also represents a convenient linearization of the concept of innovative mode (regimes, trajectories, etc.), which is actually complex and difficult to summarize by means of a single uni-dimensional construct. Thus, this taxonomic model provides a rather stylized and simplified representation of the economic system, and it is important to

The typology is built up by applying these dimensions in a two-step conceptual exercise. First, sectors are divided according to the main function they assume in the economic system (Y-axis). This yields the identification of *four major sectoral groups*. Secondly, each of these four blocks is subsequently divided into two distinct sub-groups on the basis of the technological content that characterizes them (X-axis). By using these two layers of analysis, the taxonomy not only points out the function of each sector as provider and/or recipient of goods and services to other industries, but also acknowledges the presence of considerable heterogeneity within each industrial block, in line with previous related exercises in the innovation literature (Pavitt, 1984; Miozzo and Soete, 2001). Table 1 presents a summary of the main features of these various industrial blocks, pointing out their relationship to the dominant technological paradigm and some of the characteristics of their technological regimes and trajectories.²

Advanced knowledge providers (AKP) are characterized by great technological capability and a significant ability to manage and create complex technological knowledge. Two sub-groups of industries belong to this category: (1) within manufacturing, specialized suppliers of machinery, equipment and precision instruments; (2) within services, providers of specialized knowledge and technical solutions like software, R&D, engineering and consultancy (so-called knowledge-intensive business services). What these industries have in common is that, in addition to their high level of technological capability, they perform the same function in the innovation system as providers of advanced technological knowledge to other industrial sectors. They represent *the supporting knowledge base* upon which innovative activities in all other sectors are built, and they continuously upgrade and renew this base. Firms in these industries are typically small, and tend to develop their technological activities in close cooperation with their clients and with the users of the new products and services they create. In the Fordist model, the typical example of this kind of user-producer interactions was Pavitt's illustration of the close ties between specialized suppliers and car producers in the automotive industry. In more recent times, the greater technological specialization and deeper division of labour have increased the demand for complex innovative capabilities, leading to the emergence and rapid growth of knowledge-intensive business services, which now act as providers of specialized

acknowledge and emphasize the sense of multi-dimensionality that underlies these two conceptual dimensions.

² The table can be directly compared to the corresponding tables in Pavitt (1984, p. 354) and Miozzo and Soete (2001, p. 161), which, as pointed out, represent two major previous taxonomic exercises for the study of sectoral patterns of innovation in manufacturing and service industries respectively.

knowledge and technical solutions for the other advanced branches of the economic system.

Supporting infrastructural services (SIS) may be located, similarly to the previous category, at an early stage of the vertical chain, since they mostly produce intermediate products and services rather than items for personal consumption. Where they differ from advanced knowledge providers is in terms of their technological capability, especially their more limited ability to develop new knowledge internally. Their innovative trajectory tends to be based on the acquisition of machinery, equipment and various types of advanced technological knowledge created elsewhere in the economic system. Two sub-groups of sectors can be distinguished here, each characterized by a different level of technological sophistication (Miozzo and Soete, 2001): (1) providers of distributive and physical infrastructure services (e.g. transport and wholesale trade); (2) providers of network infrastructure services (such as finance and telecommunications). Firms in the latter group typically make heavy use of ICTs developed by other advanced sectors in order to increase the efficiency of the productive process and the quality of their services, whereas the former group of industries has significantly less capability in this respect. Regardless of these differences, what these sectoral groups have in common is the function they assume in the economic system: they represent *the supporting infrastructure* upon which business and innovative activities carried out by firms in the whole economy are based. The more advanced this infrastructure is, the easier the process of intersectoral knowledge diffusion within the domestic economy, and the more efficient and productive the national system will be.

Sectors producing *mass-production goods (MPG)* constitute a key part of the manufacturing branch. They may be located at an intermediate stage of the vertical chain, since they produce both final goods and intermediate products used in other stages of the production process. In terms of their technological content, they are characterized by their considerable capability to develop new products and processes internally, although two distinct sub-groups may be distinguished (Pavitt, 1984): (1) scale-intensive industries (e.g. motor vehicles and other transport equipment) frequently have their own in-house R&D facilities, and their innovative activities also develop in close cooperation with the specialized suppliers of precision instruments and machinery; (2) science-based sectors (such as electronics) are characterized by a greater ability to create new technological knowledge internally, and their innovation processes stay close to the scientific advances continuously achieved by universities and other public research institutes. Different as they may be, these sectoral groups share several common characteristics. Firms are typically large, and their

profitability depends on the exploitation of scale economies that can be obtained through the mass production of standardized goods. Further, they all assume a central position in the knowledge chain, as they receive technological inputs from advanced knowledge providers, while in turn providing technological outputs (new products) that are used by infrastructural services as well as by producers of final goods. They are, in a nutshell, *the carrier industries* of a new technological paradigm (Freeman and Louça, 2001). By producing technologically advanced products on a large scale, by fostering the efficiency and quality of the production process of infrastructural and final goods and services, and by increasing the demand for specialized solutions from advanced knowledge providers, this group of industrial sectors plays a pivotal role in the economic system.

In the fourth sectoral block we find the producers of *personal goods and services (PGS)*. Located at the final stage of the vertical chain, these manufacturing and service industries are characterized by a lower technological content and a more limited ability to develop new products and processes internally. Their dominant innovation strategy is typically based on the acquisition of machinery, equipment and other types of external knowledge produced by their suppliers, while they commonly lack the capability and resources to organize and maintain their own R&D labs. This explains the term *supplier-dominated* industries that is frequently adopted in the innovation literature – and that describes well the two sub-groups of industries included in this category: (1) the producers of personal goods and (2) the providers of personal services (Pavitt, 1984; Miozzo and Soete, 2001). Firms in these manufacturing and service branches, typically small enterprises, are mostly recipients of advanced knowledge. To the extent that they are able to implement new technologies created elsewhere in the economy, they may use them to increase the efficiency of the production process as well as to improve the quality of the final goods and services they commercialize. This type of strategy may help to lengthen the industry-life cycle of these mature industrial sectors and recreate new technological opportunities.³

In a nutshell, this sectoral typology presents a stylized view of some of the main vertical linkages between manufacturing and business ser-

³ It is important to emphasize the multifaceted nature of the concept of *opportunity* that is so frequently used in the innovation literature. Table 1 and the related discussion in this section focus on *technological opportunities*, in line with the emphasis on technological paradigms, regimes and trajectories that inspires the new taxonomic model. However, for some industrial sectors, *market opportunities* may frequently be an equally important driver of structural change and competitiveness. For instance, in some medium- and low-tech industries, demand differentiation plays a relevant role, as firms progressively seek to improve the quality of traditional products and to produce new items in keeping with new tastes and demand changes (Von Tunzelmann and Acha, 2005). By focusing on technological rather than market opportunities, our taxonomic model emphasizes the supply-side determinants of structural change, while neglecting some important demand-side drivers.

vices within a national system of innovation. One relevant aspect of this Schumpeterian taxonomic model is the explanation it provides of the mechanisms that drive growth and structural change in national systems of innovation. When a new technological paradigm emerges and diffuses throughout the economy, industrial sectors differ greatly in terms of the technological opportunities, capabilities and constraints they face. High-opportunity technological regimes are in a better position to exploit the advantages of the new general-purpose technologies, and have a greater growth potential. Some of these industries belong to our *mass-production goods* sectoral group. By demanding new infrastructural services as well as advanced specialized knowledge and technical solutions to their suppliers, they transmit part of this growth potential to some of the other industrial groups.

To illustrate, under the Fordist paradigm, the typical high-opportunity mass-production sectors included the chemical, plastics and automobile industries (Freeman et al., 1982). In order to follow their dynamic trajectories, these branches fostered the growth of specialized suppliers (e.g. producers of precision instruments) and of infrastructural services (in particular, physical infrastructural services like transport). It was the set of mutual interactions between these vertically integrated branches of the economy that sustained the dynamics of national systems in many advanced countries in the post-war era.

More recently, with the emergence and rapid diffusion of the ICT-based paradigm, greater technological opportunities can instead be found in other sectors. Electronics and hardware producers may be seen as the high-opportunity mass production manufacturers of the present age. In their dynamic trajectory, these sectors have, however, also sustained the rise of advanced knowledge providers (such as software and technical consultancy) and of network infrastructure services (e.g. telecommunications). It is the exchange of advanced knowledge, goods and services among these high-opportunity manufacturing and service sectors that accounts for the bulk of the growth potential of the current era.

In short, the specific key industries will differ in any given historical age, but the overall causation mechanism that drives the dynamics of the system remains, by and large, the same. A new set of general-purpose technologies will need to be produced on a large scale, supported by an efficient infrastructure and sustained by the provision of an advanced knowledge base. This new four-group typology provides a comprehensive and general framework that accounts for the dynamics of a national system within each paradigmatic phase, as well as for

the transformations that occur when a regime shift changes the locus of technological opportunities and of the related growth potential.⁴

This theoretical view has one important implication for the competitiveness of national systems. Given the existence of a web of vertical linkages among industries, a specialization pattern in advanced manufacturing industries fosters the development of new services, and the latter in turn acts to enhance the growth of the former. The key mechanism of competitiveness of a national system is thus related to two major factors: first, the ability of a country to undertake a process of structural change from traditional to GPT-related high-opportunity manufacturing and service industries; secondly, the intensity of intersectoral linkages between different types of sectoral groups within the domestic economy.

The second paper in this phase of the project, presented by Castellacci (2008c), takes this conceptual framework as a starting point and aims at empirically investigating the main theoretical properties of this new sectoral taxonomic model. In fact, this type of theoretical perspective – according to which the key mechanism of structural change is related to the emergence and diffusion of ICT-related innovations – raises interesting questions that need to be confronted with empirical evidence. Three interrelated questions are empirically examined in this paper: (1) Is it effectively the case that industries that are more closely related to the production and use of the new general purpose technologies (GPTs) have recently improved their productivity performance? (2) To what extent is this productivity dynamics related to the technological capability and innovative activities of industrial sectors? (3) What are the country-level implications of this process of structural change – does the latter affect the growth rate of national economies?

The theoretical framework that is adopted in this paper is based upon the new sectoral taxonomy developed in this phase of the project. Building on the previous one, this second paper puts forward a new analytical model of GPT diffusion, structural change and productivity growth. In line with the new sectoral taxonomy, the analytical model identifies various groups of manufacturing and service industries, and points out their distinct technological characteristics and the different function they assume in the economic system as providers and/or re-

⁴ This is an aspect where the new taxonomy differs substantially from related works in this field. The main purpose of previous taxonomic exercises was more to point out the existence of industries characterized by distinct innovative modes in a given historical period (e.g. in the post-war era, as in Pavitt's taxonomy), rather than exploring the implications of a given industrial structure for the dynamics of the economic system. The taxonomy presented here, by making explicit the link between paradigms, regimes and trajectories, tries to link the identification of sectoral patterns in a static sense with the study of structural change and economic dynamics in the long run.

ipients of advanced knowledge, goods and services to/from the other sectors. The model argues that, when a new set of GPTs emerge and diffuse throughout the economy, these sectoral groups greatly differ in their ability to exploit the technological opportunities provided by the new technological paradigm. ICT-related manufacturing and service industries are supposedly those that are in a better position to transform technological opportunities into productivity increases, and for this reason are expected to experience a more dynamic performance.

The paper investigates these questions by making use of two recent and updated data sources. The first is the EU KLEMS database, a novel dataset that provides data on labour productivity and several other indicators of the economic characteristics of industrial sectors (2-digit level) for all manufacturing and service industries for the period 1970-2005 (EU KLEMS Database, March 2008; see Timmer et al., 2007). The second is the Fourth Community Innovation Survey (CIS4), which provides a rich set of information on innovative activities, strategies and linkages of industrial sectors in Europe in the more recent period 2002-2004. The econometric analysis examines these data by means of both cross-sectional methods and dynamic panel model techniques (Arellano and Bond, 1991), the advantage of the latter being their ability to tackle the well-known problem of endogeneity (simultaneity) in the analysis of the innovation-productivity relationship.

The results of the paper do on the whole provide robust empirical support for the validity of the theoretical model based on the new sectoral taxonomy. First, the econometric results provide clear evidence that a process of industrial transformation and structural change has taken place in the OECD area over the period 1970-2005. In the shift from the end of Fordism to the beginning of the new ICT-based age, sectoral groups that are closer to the core of the new GPTs have visibly improved their productivity performance, whereas other more traditional industries have experienced a more stagnant trend.

Secondly, investigating the possible determinants of the sectoral productivity dynamics in a more recent period, the work highlights some major factors that are positively related to the growth of industrial sectors, and in particular (1) their technological capability (measured by their human capital, innovation output, innovation strategies and trajectories) and (2) their ability to acquire external knowledge from other industries (measured by the intensity of inter-sectoral linkages and the intensity of use of ICT capital). The paper also finds that the effects of these factors on the productivity dynamics differ substantially across the sectoral groups of the GPT model.

Thirdly, shifting the focus to the aggregate (country-level) implications of the model, the study presents evidence in support of the idea that the long-run performance of national economies is positively related to the three main factors highlighted by the model: (1) countries' overall level of innovative capability, (2) their intensity of external knowledge acquisition, and (3) their ability to undertake a process of structural change towards high-opportunity (new GPT) sectoral groups, and particularly science-based manufacturing and network infrastructure services.

The two industry-level studies presented in this phase of the project have important implications for policy. The taxonomic model, in a nutshell, suggests that it is the interaction between technologically advanced manufacturing and service industries that sustains the dynamics of national systems in each long-run paradigmatic phase. In order to sustain their international competitiveness, national systems should ideally build up and maintain a sophisticated branch of advanced knowledge providers, an efficient set of supporting infrastructure services and a strong mass-producing manufacturing base. In this ideal scheme, the dynamics of the latter supports, and is supported by, the growth of the former groups of industrial sectors. Each national economy should therefore make an active effort to transform its industrial structure towards the most progressive industries of a given historical age, so to make it more congruent with the requirements and opportunities provided by the emergence and diffusion of a new set of general-purpose technologies.

This broad policy implication, although reasonable and widely shared, requires a long-run commitment and considerable resources that may be hard to find in a short time-horizon. Such a long-term strategy should therefore be complemented by other types of shorter-term and more specific policies that may have a more immediate effect on the dynamics of a national system. These policy measures should be based on the sector-specific nature of innovative activities, targeting the specific characteristics, obstacles and opportunities that characterize technological activities in various industries of the economy – instead of implementing a generic scheme of R&D support for all industrial sectors.

The focus on industry-specific regimes, trajectories and vertical linkages draws attention to the variety of innovative patterns that have been pointed out in this phase of the project (and that will also constitute a basic pillar in the next two phases). On the one hand, the performance of the group of high-opportunity industries that are more closely related to the new technological paradigm (advanced knowledge providers, science-based and network infrastructure services) can

be enhanced by policies designed to foster their overall level of innovation intensity and strengthen the intensity of interactions with the advanced users of new technologies and with the public S&T system. On the other hand, it is also possible to sustain the competitiveness of sectors that face lower opportunities and less dynamic trajectories in the new ICT-based age (scale-intensive, physical infrastructure services, supplier-dominated). The crucial challenge for industries of this type is to strengthen their linkages with more technologically advanced branches of the economy, so as to enable the process of intersectoral knowledge diffusion that may generate new opportunities and lengthen the industry-life cycles of these mature sectors. Public policies can accelerate this process, for instance, by supporting the acquisition of advanced machinery, equipment, software and external knowledge from specialized suppliers, and by increasing the intensity of supplier-producer interactions.

While the main intention of this phase of the research has been to combine manufacturing and services within the same comprehensive framework, we have also noted, in line with the literature, the existence of several peculiarities in the process of knowledge creation in services. These peculiarities are indeed important, and innovation policies must take them into due account. Three of them appear particularly relevant in light of the empirical evidence presented in these two papers. First, the great importance of customization and interactivity emphasizes the role of user-producer interactions and of policies that may strengthen linkages of this type. Secondly, the relevance of human resources and capabilities for the performance of service firms should draw the attention of policy-makers to the role played by training activities and organizational changes – that may prove to be a more crucial factor of competitive advantage in services than the amount of resources spent on R&D investments. Finally, the lower reliance on formal means of appropriability (e.g. patents) in services requires a rethinking of the policy rationale that is commonly adopted for the protection of innovative results.

Figure 3: A new taxonomy of sectoral patterns of innovation in manufacturing and service industries (source: Castellacci, 2008b)

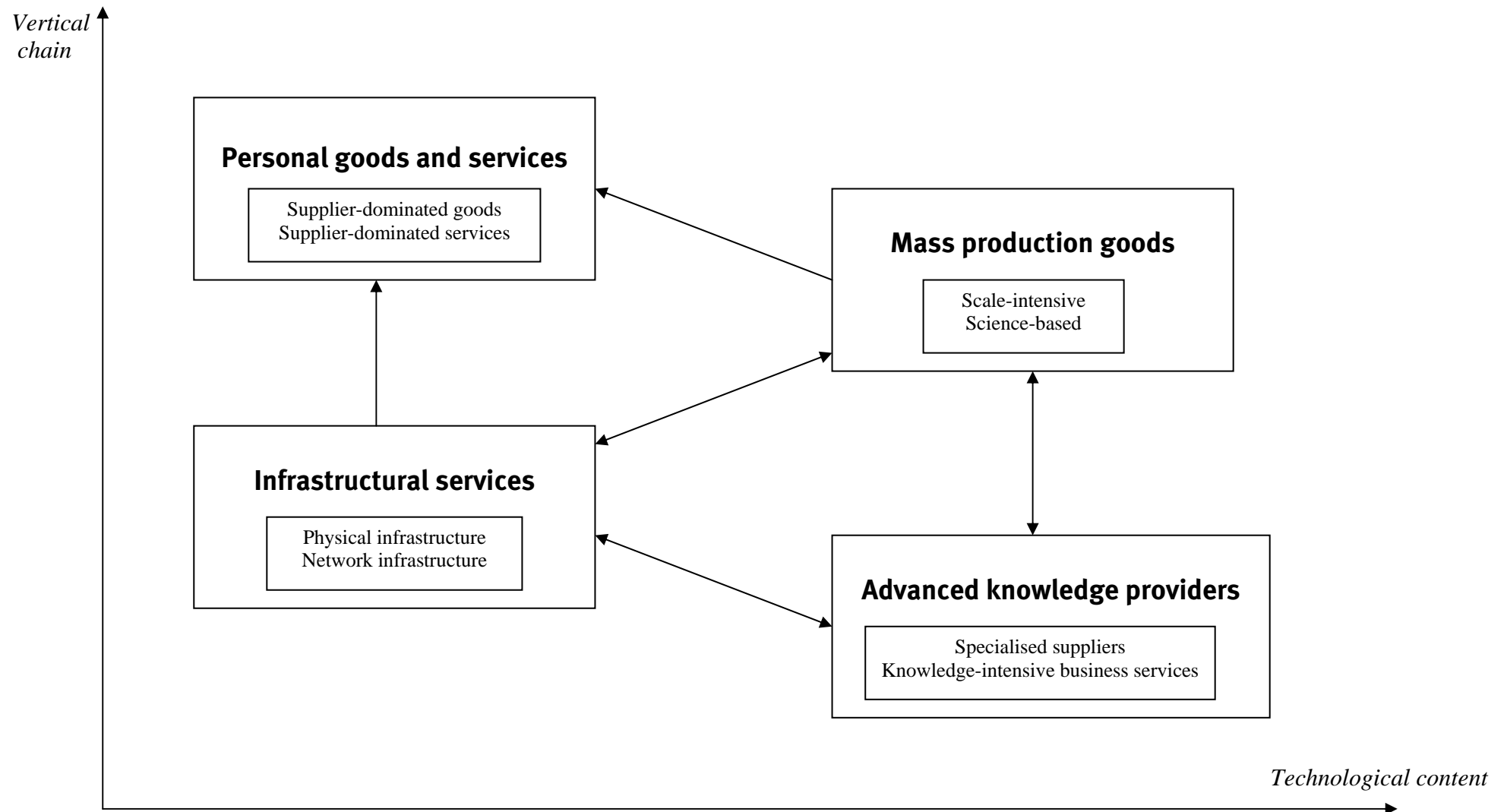


Table 1: The main characteristics of the various sectoral groups in the new taxonomy (source: Castellacci, 2008b)

Sectoral category	Sub-groups within each category	Typical core sectors	Major function and relationship to technological paradigms	Technological regimes	Technological trajectories
Advanced knowledge providers	Knowledge-intensive business services	Software; R&D; Engineering; Consultancy	The supporting knowledge base of the ICT paradigm	<i>Opportunity levels:</i> very high <i>External sources:</i> users and Universities <i>Appropriability:</i> Know-how; copyright <i>Dominant firm size:</i> SMEs	<i>Type of innovation:</i> new services; organizational innovation <i>Innovation expenditures and strategy:</i> R&D; training; cooperations
	Specialised suppliers manufacturing	Machinery; Instruments	The supporting knowledge base of the Fordist paradigm	<i>Opportunity levels:</i> high <i>External sources:</i> users <i>Appropriability:</i> patents; design know-how <i>Dominant firm size:</i> SMEs	<i>Type of innovation:</i> new products <i>Innovation expenditures and strategy:</i> R&D; acquisition of machinery; software purchase
Mass production goods	Science-based manufacturing	Electronics	The carrier industries of the ICT paradigm	<i>Opportunity levels:</i> high <i>External sources:</i> Universities and users <i>Appropriability:</i> patents; design; copyright <i>Dominant firm size:</i> large	<i>Type of innovation:</i> new products; organizational innovation <i>Innovation expenditures and strategy:</i> R&D; cooperations
	Scale-intensive manufacturing	Motor vehicles	The carrier industries of the Fordist paradigm	<i>Opportunity levels:</i> medium <i>External sources:</i> suppliers and users <i>Appropriability:</i> design; processy secrecy <i>Dominant firm size:</i> large	<i>Type of innovation:</i> mixed products and process innovation <i>Innovation expenditures and strategy:</i> R&D; acquisition of machinery;
Supporting Infrastructure Services	Network infrastructure services	Telecommunications; Finance	The supporting infrastructure of the ICT paradigm	<i>Opportunity levels:</i> medium <i>External sources:</i> suppliers and users <i>Appropriability:</i> standards; norms; design <i>Dominant firm size:</i> large	<i>Type of innovation:</i> mixed process, service and organizational innovation <i>Innovation expenditures and strategy:</i> R&D; acquisition of software; training
	Physical infrastructure services	Transport; Wholesale trade	The supporting infrastructure of the Fordist paradigm	<i>Opportunity levels:</i> low <i>External sources:</i> suppliers <i>Appropriability:</i> standards; norms; design <i>Dominant firm size:</i> large	<i>Type of innovation:</i> process <i>Innovation expenditures and strategy:</i> acquisition of machinery and software
Personal goods and services	Supplier-dominated goods	Textiles and wearing	They enhance the quality of final products and services by acquiring and embodying technologies related to different paradigms	<i>Opportunity levels:</i> medium <i>External sources:</i> suppliers and end users <i>Appropriability:</i> trademarks; design know-how <i>Dominant firm size:</i> SMEs	<i>Type of innovation:</i> process <i>Innovation expenditures and strategy:</i> acquisition of machinery
	Supplier-dominated services	Hotels and restaurants		<i>Opportunity levels:</i> low <i>External sources:</i> suppliers <i>Appropriability:</i> non-technical means <i>Dominant firm size:</i> SMEs	<i>Type of innovation:</i> process <i>Innovation expenditures and strategy:</i> acquisition of machinery; training

2.2 Part 2 – Firm-level studies of industrial dynamics, innovation and the economic performance of Nordic service industries

The second phase of the project shifts the focus to the microeconomic level of analysis. Firm-level empirical studies of innovation and economic performance have increasingly become popular in the last few years, and this has certainly had much to do with the greater availability of detailed information on technological activities and the economic performance of thousands of enterprises (e.g. the data from the *Community Innovation Surveys* in Europe). This phase of the project is rooted in this increasingly important scientific trajectory, so-called microeconometrics of innovation, but it proposes one major step forward. Instead of simply focusing on the link between input, output and performance of innovation as most microeconomic studies have done so far, we introduce and emphasize one major aspect that has not yet received the careful attention it would deserve: the role of sector-specific conditions. While the industry-specific nature of innovative activities is by now a well-established conceptual pillar in innovation studies, econometric studies at the enterprise-level do usually deal with this issue in a rather simplified manner (e.g. by introducing sector dummies in the regression model). The two empirical studies presented in this phase of the project emphasize the importance of sectoral characteristics, both of a technological and market-related nature, and argue that the relationship between innovation and firm performance may differ substantially in different types of markets, since industries greatly differ with respect to the technological environment and industrial dynamics conditions that they provide to enterprises.

In the first paper of this part of the project, Castellacci and Zheng (2008) carry out an empirical study of the relationships between innovation and productivity growth of Norwegian firms, and focus in particular on the role played by sectoral technological regimes and industrial dynamics conditions. The general idea motivating the study is that the relationship between innovation and productivity growth may have a well distinct nature in different types of markets and industrial sectors. Therefore, in order to refine the understanding of the innovation-productivity link, there is a need a theoretical approach that takes into account the sector-specific nature of technological change (Dosi, 1988; Malerba, 2002; Laursen and Meliciani, 2002). More specifically, the paper explores the idea that the sources and mechanisms of productivity growth may be distinct in different types of sectoral market structure and industrial dynamics conditions. In a Schumpeter Mark II regime, the oligopolistic and concentrated nature of the market may make large incumbent innovators the dominant carriers of productivity growth. In contrast, the dynamics of productivity in a Schumpeter Mark I pattern may be led by an intense and turbulent

process of competition where new innovators are more productive than the exit firms they replace.

In exploring this main idea, it is crucial to distinguish and measure different sources of productivity growth. The paper makes use of frontier production function methods (data envelopment analysis) to decompose the growth of total factor productivity (TFP) into two distinct components: *technical progress* and *technical efficiency* (Färe et al. 1994; Zheng et al., 2003). The former is associated with changes in the best-practice production frontier, whereas the latter with other productivity changes, such as learning by doing, improved managerial practices, and change in the efficiency with which an existing technology is applied.

Besides analysing the dynamics of productivity (TFP) of Norwegian firms by means of this decomposition method, the empirical study also investigates the relationships between TFP growth and technological regimes in different manufacturing and service industries. The econometric study makes use of firm-level data for the Norwegian economy. The rich dataset combines together information from three different sources. Data for the estimation and decomposition of TFP are taken from a time series database that provides information on several thousands of Norwegian enterprises for the period 1998-2004. Data on innovative activities are from the *Third* and the *Fourth Community Innovation Survey* for Norway, referring to the 1998-2000 (CIS3) and 2002-2004 (CIS4) periods respectively. These three data sources all provide information on a very large sample of Norwegian enterprises in all manufacturing and service industries of the economy.

The main results of the paper can be summarized as follows. First, the productivity decomposition exercise indicates that in the period 1998-2004 TFP growth has mostly been obtained through technical progress, whereas technical efficiency has on average decreased. The technological regime type of model that is put forward to investigate the determinants of these two distinct components appears to perform reasonably well in the econometric estimations, and provides basic support for the first hypothesis of the paper, namely that the characteristics of technological regimes are important determinants of the productivity growth of firms. Specifically, both components of productivity growth are significantly related to the level of technological opportunities (as measured by the acquisition of external knowledge), other sources of opportunities within the same firm, the ability of the enterprise to increase market shares and entering new markets, as well as a set of other firm-specific characteristics such as size, export orientation and the average length of the product cycle.

Secondly, the econometric results also indicate that some of the explanatory variables in the model have different effects on the two distinct components of productivity growth. This provides support for the second hypothesis put forward in the paper (i.e. that the impacts of technological regime-related factors on technical progress are different from the effects on efficiency change). In particular, internal R&D efforts and the cumulativeness of R&D activities are important factors for the dynamics of technical progress but not for efficiency change. Among the external sources of opportunity, competitors on the same market are important for technical progress, whereas interacting with the consultants seems to constitute a more relevant factor to achieve efficiency improvements. Increases in the productive capacity of the firm are, quite obviously, positively related to technical progress but negatively linked to the efficiency component. Last, the level of TFP shows a strong negative (positive) relationship with technical progress (efficiency change), thus possibly suggesting a possible trade-off in the short-run between the efforts devoted to the introduction of new technologies and the achievement of high efficiency in the utilization of existing techniques.

Thirdly, the empirical results also provide support for the idea that the relationships between technological regimes, technical progress and efficiency changes work differently in different Schumpeterian patterns of innovation (which is the third specific hypothesis formulated in the paper). In the piecewise linear regression version of the econometric model, many of the explanatory variables turn out to have different estimated coefficients in the Schumpeter Mark I and in the Schumpeter Mark II regimes. This is particularly the case in the technical progress equation, where several regressors significantly differ among the regimes (e.g. cumulativeness, group structure, length of the product life, market location, lack of technological information as a main hampering factor). These results also indicate that the technical progress component of TFP growth has proved to be significantly more dynamic for firms in the Schumpeter Mark II regime, whereas the efficiency change component has been higher for enterprises in the Schumpeter Mark I type of markets.

The overall interpretation of these results is that the mechanism of productivity growth differs in the two Schumpeterian regimes. While Schumpeter Mark II markets are characterized by an oligopolistic structure where large incumbent innovators continuously and cumulatively push the technological frontier further (technical progress), firms in Schumpeter Mark I industries must pay close attention to make an efficient use of already available techniques (efficiency change), which is a crucial requirement to survive in competitive and turbulent markets.

The second paper of this phase of the project is the one where Tingvall and Karpaty (2008) study the relationships between innovation, R&D and competition for a very large sample of Swedish enterprises in the service sectors. Similarly to the first one, this second paper does also aim at studying the relationships between sectoral market conditions and firm performance. Differently from the previous one, however, this paper focuses on market competition as the major sectoral condition of interest (rather than technological regimes in a broader sense), and innovation as the main firm performance variable (instead of TFP measures of technological progress and efficiency).

The literature on the interrelationships between competition and innovation has for a long time attracted the attention of academic scholars and policy makers, but it still constitutes a debated and unsettled issue in the economics of innovation literature. In addition, most previous studies in this branch have focused on manufacturing industries and neglected the service sectors. Despite the economic impact of the service sectors, relatively little is known about how the innovative activities and performance of service sector firms respond to competition. This is where the Tingvall and Karpaty (2008) paper contributes to the literature.

According to Schumpeter (1934) the monopoly deadweight loss is the price that an economy has to pay to finance and stimulate firm R&D. That is, increased competition leads to less R&D and a lower rate of innovation and economic growth. The Schumpeterian argument is that competition reduces the expected pay-off from R&D and therefore contracts firm R&D. This prediction has however triggered a number of previous papers that in contrast to Schumpeter's view have shown that increased competition may also stimulate innovation and R&D.

In an important recent contribution, Aghion *et al.* (2005) combine theories on competition and R&D showing that the positive impact of competition on R&D dominates when the level of competition is low, whereas in markets that are already highly competitive further increases in competition may by contrast decrease firm R&D and innovation performance. That is, an inverse U-shaped relationship between competition and innovation is found. The intuition behind the positively sloping segment – the escape competition effect – is that the more neck-to-neck the market competition the greater the pay-off from gaining an edge over the competitors. Hence, if competition is fierce, firms may have an incentive to escape competition by innovating. On the other hand, as predicted by the Schumpeterian model, at high levels of competition profits will be limited making it hard to cover R&D expenditures. Hence, competition may in this context hold

back R&D. Put together, these two contradicting forces give rise to an inverse U-shaped relationship between competition and R&D. This interesting finding by Aghion *et al.* (2005) refers to a sample of firms in manufacturing industries, and Tingvall and Karpaty (2008) investigate for the first time whether a similar inverted U-shaped relationship holds for enterprises in the service sectors as well.

The firm-level data they use stem from Statistics Sweden (SCB), and it is a very rich panel dataset covering the years 1997-2005. Four different databases have been merged together: the (i) the Financial Statistics (FS) Database, (ii) the R&D survey and (iii) the Regional Labor Market Statistics Database (Rams). These three register databases include all manufacturing and services firms. Combining this data provides information not only on the profit and loss account of firms, and the associated variables such as gross production and value added, employment, capital stock, purchases of other inputs, R&D expenditure etc., but also detailed information on education by firm. In addition to these three register based datasets the paper uses additional information on firms innovation efforts from the “Innovation Activity in Swedish Enterprises Surveys” (CIS). CIS data used here are drawn from the CIS 2-survey 1994-1996, CIS 3-survey 1998-2000, CIS 4-survey 2002-2004 and CIS 5-survey 2004-2006. From these four CIS Surveys, it is possible to get detailed information on firms’ expenditures on intramural R&D, extramural R&D, external knowledge and on whether the firms cooperate with competitors and other partners.

This rich dataset is analysed by means of panel estimation techniques, whose main advantage is to take into account the possible endogeneity and simultaneity of the competition-innovation relationship. The results of these panel data estimations confirm the existence of an inverted U-shaped relationship between competition and innovation in the service sectors in Sweden. This main pattern turns out as a robust econometric result and provides an interesting fact for the analysis of innovation and performance in services.

However, at a more detailed of analysis some of the econometric results deviate from this general picture and provide further useful indications on the working of this relationship. First, R&D activity in non-exporting firms has a weaker connection to competition and does not display an inverse U-shaped relation to competition. Hence, available measures of competition signal that non-exporting service firms might react differently to competition from exporting firms.

Secondly, in order to broaden the picture of firms’ reaction pattern the paper also analyses alternative responses to competition from different types of innovative activities. More specifically, it separates innova-

tive activities into different types: expenditures in intramural R&D, expenditures in extramural R&D and expenditures for acquisition of external knowledge. The paper finds evidence for an inverted U-shaped relation not only for intramural R&D but also for training expenditures and for the acquisition of external knowledge. However, as competition goes up there is a tendency for a reallocation from extramural to intramural R&D. This can be taken as an indication of either a home preference for local R&D or as an indication of Sweden being a relatively competitive country as a location for R&D.

Thirdly, the econometric analysis investigates how the propensity for participating in strategic alliances is affected by competition. The results indicate that small and large firms do behave differently from each other. There is a tendency for small firms to seek more strategic alliances as competition goes up while the opposite is found for large firms. These contradicting observations may be explained by small firms' limited capacity to take on large innovation projects by themselves when – at the same time – increasing competition makes it crucial to be at the technological frontline. By contrast, for large firms, that have a larger internal capacity to handle innovation projects, the pay off of an incremental edge to the competitors increases as competition becomes more fierce (neck-to-neckness), giving an argument for not sharing new discoveries with competitors.

On the whole, a general implication of the paper is that the inverse U-shape found suggests that the risk that increasing competition may lower R&D and innovation intensities is admittedly limited. The overall policy conclusion is that the negative effect of stimulating increased competition on R&D and innovation is negligible. In low competition markets, R&D activity increases with competition. In markets where competition is already very fierce, a further increase may lower the incentives to innovate. Policies that require firms to set lower prices and lower the entry barriers is arguably not a useful option in markets that are already close to perfect competition.

2.3 Part 3 – Firm-level studies of innovation, competitiveness and the internationalization of Nordic service industries

As previously pointed out, one relevant aspect of the growing importance of the service sectors in modern economies refers to their internationalization patterns. The rapid diffusion of ICTs and the strong technological dynamism that characterizes the provision of new services in many industries of the economy have in recent decades increased the scope for service tradability and internationalization (Hoeckman and Primo Braga, 1997). Most of the literature studying

the relationships between innovation and international performance has so far focused on manufacturing industries and frequently neglected the service sectors (see discussion in section 1.2). Motivated by this research gap in the literature on internationalization and competitiveness, this third part of the project provides a set of four firm-level empirical studies that analyse the complex relationship and feedback mechanisms that link innovation, competitiveness and internationalization within the context of the Nordic economies.

The first empirical paper is the one by Castellacci (2008d). The paper is motivated by the fact that one of the main factors hampering the progress of research on service internationalization has until recently been the lack of reliable data material and systematic empirical evidence to study patterns and determinants of the international activities of service providers (Narula and Zanfei, 2005; Carlsson, 2006). The study contributes by bringing new empirical evidence on this phenomenon. It presents the results of a new survey that was carried out among a relatively large sample of Norwegian enterprises in several service sectors during the year 2007. The survey gathers new information on the main channels of internationalization, and the related strategies, objectives and hampering factors. This fresh empirical evidence enables to investigate the main internationalization patterns, their determinants, and how these differ across service sectors. The main phase of data collection was carried out by means of a web-based survey, which was sent to a total number of 1290 enterprises in 12 service sectors. Only firms with more than 20 employees were selected for the web-based survey. After a series of reminders during the whole data collection period, a total number of 302 enterprises filled in the on-line form and returned the questionnaire, corresponding to a satisfactory response rate of 23,4%.

The empirical analysis of this novel survey dataset carries out three main tasks. The first is the study of the relevance of different internationalization channels. The survey aims at obtaining a mapping of the relative importance, and underlying characteristics and strategies, of three main aspects: international sales (e.g. through trade and FDI), international cooperations and R&D outsourcing. These three channels by and large correspond to the three categories of the well-known taxonomy of the globalisation of innovation (Archibugi and Michie, 1995; Archibugi and Iammarino, 1999). The survey adopts this useful typology as the main conceptual framework, and tries to operationalize it by asking Norwegian service enterprises a number of questions regarding their international activities and strategies with respect to each of these three aspects.

The second objective is to explore the possible determinants of the observed internationalization patterns. The work investigates the relationships between the various internationalization channels and a set of firms' characteristics. Two possible determinants assume particular relevance in this study: (1) the innovative capability of an enterprise; (2) its simultaneous adoption of multiple internationalization channels. This latter factor explores whether the various internationalization strategies may represent complementary or substitute strategies in the internationalization process of service firms.

The third task of this empirical analysis is the effort to go beyond the identification of overall (average) patterns and relationships and the attempt to uncover cross-sectoral differences in the international activities of service providers. The great variety of innovative modes that characterizes different service sectors has been extensively documented in the literature (Evangelista, 2000; Drejer, 2004; Miles, 2005). In particular, the paper follows the sectoral taxonomy developed in the first phase of the project (see section 2.1) and single out four groups of service industries that differ in terms of their function in the economic system and innovative capability: advanced knowledge providers services, personal services, network infrastructure services and physical infrastructure services. The paper argues that the industry-specific context has an important effect on firms' internationalization activities and patterns, since it contributes to shape the enterprises' propensity to compete in international markets as well as their capability to do so. Following this main idea, the study analyses sectoral differences and point out the industry-specific international profile that may be associated to each sectoral group of the sectoral taxonomy.

The newly collected empirical evidence and related analysis lead to three main results, each related to the three objectives outlined above here. First, regarding the three different internationalization channels, the descriptive analysis of the survey results indicate that two of them, international sales and international cooperations, are used by a substantial share of firms in the sample, whereas the third one, R&D outsourcing, is much more limited in scope (and mostly used by enterprises in knowledge intensive business services). For all the three channels, firms that seek to expand their activities overseas seem to be motivated by two major objectives: to get access to foreign production and distribution networks and to search for advanced human capital. Exporting is one of the main delivery modes in international markets. However, the relevance of other delivery modes (e.g. temporary and permanent presence abroad, mobility of foreign clients) suggests that the co-terminality of production and consumption of services is still an important issue, and that geographical and cultural proximity still mat-

ter substantially in the internationalization process of service providers.

Secondly, this new survey data enables an investigation of the possible determinants of the various internationalization channels. Despite the obvious limitations of this type of empirical analysis in a cross-sectional setting, some interesting indications (correlations) emerge from the probit regression exercise. The international performance of service firms is related to the following main factors: (1) the sectoral group to which the enterprise belongs, because the function of each sectoral group affects the propensity to engage in international activities; (2) the innovative capability of the enterprise, which determines its technological competitiveness in foreign markets; (3) the availability of infrastructures (e.g. transport and distribution channels) and skilled labour in overseas markets; (4) other internationalization channels. This latter factor turns out to be particularly important in the regression model, and its relevance suggests that the various channels of internationalization may be complement, rather than substitute, strategies that service firms adopt in order to compete in international markets.

Thirdly, it is important to emphasize that the overall patterns and determinants pointed out above here refer to the whole sample of firms under investigation, whereas significant differences emerge in internationalization patterns, strategies and performance across service sectors. Both the ANOVA exercise and the piecewise version of the probit regression model (i.e. the regressions including slope dummies for the various sectoral groups) indicate in fact the existence of important sectoral specificities in the internationalization process. In particular, the four sectoral groups that have been considered throughout this paper differ substantially in terms of their innovative capability and international performance. The bunch of firms in the advanced knowledge providers sectoral group emerge as the most active in foreign markets, and make active use of all three channels, sales, cooperations and R&D outsourcing. Physical infrastructure services do also perform well in overseas markets, although, differently from the previous group, they seem to base their dynamics on existing rather than innovative services. On the other hand, Norwegian enterprises in the sectoral groups of network infrastructure and personal services are characterized by a more limited scope and ability to compete in international markets.

Laursen (2008) presents the second study in this phase of the project, which focuses on innovation and the internationalization process of Danish firms. While the Castellacci (2008d) study is more general in scope and analyses various different internationalization channels,

Laursen (2008) focuses more explicitly on one of the most important of these channels: exports. The paper aims at investigating the main determinants of export performance of Danish enterprises with a particular emphasis on the role played by innovative activities and vertical linkages.

The literature on firm-level export dynamics is substantial and rapidly progressing, still different research traditions investigate the themes from different perspectives. A substantial literature has documented that in a number of contexts, firms located in the same country and same industry, display different export behavior, with some firms being very global, others less global, and yet others serving the local market only (Bernard and Jensen, 1999; Greenaway and Kneller, 2007). The observed differences have been observed to include a number of firm-specific characteristics, including size, cost structure and previous export experience, as well as sector and country characteristics of the firms' external environment. An important segment of this literature has focused in particular on the role of knowledge and innovation in determining export behavior. Another branch of the literature has dealt with sources of innovation (Pavitt, 1984; von Hippel, 1988; Laursen and Salter, 2004), i.e. the stimuli that may drive innovation under specific circumstances, including stimuli from internal research and development (R&D), suppliers, customers and universities.

However, with a notable exception (Beise-Zee and Rammer, 2006), these two literatures have not previously been combined. Moreover, the firm-level export behavior literature has tended to focus on manufacturing firms, rather than on service firms, despite the fact that many services are becoming increasingly tradable. This paper aims to remedy these gaps in the literature by investigating the determinants of export behavior, focusing on internal R&D, as well as customers, suppliers and universities as sources of innovation. The study looks at both manufacturing and service firms and splits the sample according to the sectoral taxonomy developed within this project (see section 2.1) in order to unravel possible sectoral heterogeneity within the services and manufacturing branches.

The data for the analysis is drawn from the Danish innovation survey (CIS3) and from linked firm-level register data held by Statistics Denmark. The CIS3 survey was implemented in 2001 and is based on the core Eurostat Community Innovation Survey (CIS) of innovation. The survey was initially sent to 4,783 business units in Denmark in June 2001. The responses were voluntary and respondents were promised confidentiality. The final sample comprises 1,873 Danish firms in manufacturing and services. These CIS3 firm-level data are analyzed

in a cross-sectional econometric setting, where the dependent variable (share of firms' exports as a proportion of their total sales in 2000) is related to a set of innovation-related indicators from the CIS3 and other customary firm-level variables.

The findings support the idea that Danish service firms' export activities are of economic importance in that these firms are exporters to a high degree (around 50% of service enterprises have export activities). Indeed, Danish firms in manufacturing as well as in services are much internationalised. Only in the case of construction and knowledge intensive services are there more non-exporters than exporters, and even in these cases there are significant proportions of firms that sell in international markets. The sectoral group with the highest export intensity is physical infrastructure services (around 65% of firms), in line with what found by Castellacci (2008d) for the case of Norway. From a policy point of view, this high export intensity in most service industries of the economy suggests that schemes to promote the initiation of internationalization through exports may be less important than they used to be in the past — exporting activity is now more the rule than the exception for a small open economy like the Danish economy.

Moreover, the econometric results do indeed confirm the hypothesis that innovative activities are major determinants of export behavior. To be sure, the determinants of export behavior in services and manufacturing appear to be strikingly similar, in particular with respect to knowledge-related variables — in particular with respect to product and using customers as a source of innovation. This suggests that policies that promote knowledge-generation may have not been manufacturing biased as it has sometimes been suggested; rather, knowledge-generation activity appears to affect exports in most economic activities in a developed economy such as Denmark.

Process innovation and using suppliers as a source of knowledge for innovation turn out to be negatively related to export intensity. As both are related to cost reduction strategies — while Denmark is a high-income, high cost country — the interpretation is likely to be that taking part in cost competition is a disadvantage for Danish manufacturing and service firms. The name of the game for Danish firms appears to be processes related to the introduction of innovative products. This implies that policy-makers could support knowledge-generating activities that in turn may result in innovative products.

The fact that using customers as a source of innovation is associated with having a high export intensity may suggest that the importance of firms' innovative activities cannot be reduced to the resulting product

innovation and that a simple two-step production function (with an innovation function and a subsequent export function) approach may be misleading. Search for solutions in the broader innovation system — in particular using customers — has separate importance. This suggests that innovation is *systemic* and that (internal) investment in R&D is only a prerequisite for successful innovation and derived economic outcomes. The systemic context puts a premium on interactivity within and between firms, and between firms and the knowledge infrastructure. However, the *systemicness* creates more stringent demands regarding the qualifications of employees and management. The ability to combine abstract reasoning with social skills in communication and co-operation is now more important than before for being successfully integrated in the system. Accordingly, if policies are going to have an effect, policy makers need to recognize that external collaborative links are essential to success, and to support the building up of these links accordingly.

The third study on the theme of innovation and firm internationalization is the one by Laursen, Reichstein and Maskell (2008). This paper focuses on a different channel of internationalization, *offshoring outsourcing*, which is the particular type of outsourcing that has to do with such activities in lower-wage foreign countries. Private enterprises have over the past couple of decades increasingly turned towards outsourcing as an important means of achieving sustained competitive advantage. The level of outsourcing activities has therefore grown tremendously. The growth rate of outsourcing to firms in lower-wage foreign countries has in particular been outspoken.

Extant literature has dealt with the issue both from an economics as well as from a management perspective. While the economics literature has focused primarily on effects on productivity and income distribution in outward outsourcing countries and the choice of the appropriate organizational form, the management literature has discussed the conditions under which offshored outsourcing can give rise to sustained competitive advantage. Nevertheless, surprisingly little empirical research has been conducted on the costs and benefits of offshored outsourcing from a firm-level perspective. Indeed, there appears to be a need for research with an empirical anchor examining the performance of offshore outsourcing at the firm-level.

This is where the paper by Laursen, Reichstein and Maskell (2008) intends to contribute to the literature. The paper focuses on the performance of the offshored outsourced activities, and studies whether this performance is affected by the type of relationship that the outsourcing firm has with its foreign partners. In particular, the paper emphasizes the degree of the relational interaction with partners, the

degree of quality control as well as the degree of the legal formalization of the relationship. In other words, as opposed to a large chunk of the previous literature that focuses on types of activities that should or should not be outsourced, this study does instead center on the drivers of offshoring outsourcing success after the decision to outsource has been taken.

The relational view of competitive advantage provides a natural theoretical framework to undertake this empirical study. This theoretical view posits that the firms' critical resources may often span firm boundaries and may be embedded in inter-firm resources and routines, and moreover, that inter-firm knowledge sharing routines, complementary resource endowments, and effective governance are primary sources of supernormal profits. According to this view, we would expect offshore outsourced activity to become successful when the focal firm and its supplier(s) invest in exchanging and building knowledge to the mutual benefit. The underlying idea is that a firm's (alliance) partners are in many cases the most important source of knowledge for new ideas and information that results in process and product innovations. Given that an important component of knowledge is tacit, difficult to unbundle from its context ("sticky"), complex, and hence difficult to codify, knowledge is most often difficult to imitate and transfer (Nelson and Winter, 1982). Accordingly, collaboration involving person-based "broad band" interaction becomes a response to the transfer and joint learning problems.

The paper uses a rich data set based on a Danish 2004 questionnaire survey on the extent, development and significant features of inter-firm projects. The survey was conducted on behalf of a research team from Copenhagen Business School led by Peter Maskell and the Danish Ministry of the Environment. Questions in the survey pertained to the time period between 2000 and 2002. The survey was carried out by Statistics Denmark who drew a stratified sample from the Firm Accounts Register, an accounting database consisting of all Danish firms (Statistics Denmark, 2004). The final dataset contains 1645 firms available for analysis amounting to 254 observations that had engaged in offshore outsourcing activities to a low-wage country. Laursen, Reichstein and Maskell (2008) carry out an econometric analysis of this survey dataset that tries to relate the performance of firms outsourcing activities to the type of relationship (cooperation agreement) that ties together the partner enterprises.

First, descriptive evidence of the dataset indicates the existence of substantial sectoral differences among the industry-group of the taxonomy developed within the project (see section 2.1). Specialized supplier manufacturing and science-based manufacturing firms have a higher tendency to outsource to low-income countries. Of the total

frame, more than 40 percent of these types of firms have offshore outsourced activities. Within the service branch, about 12 percent of firms in knowledge intensive services have offshore outsourced. This is the highest number in services, and the sectoral share turns out to be quite similar to what found by Castellacci (2008d) for knowledge intensive firms in Norway. Besides, when knowledge intensive services have outsourced, in close to 50 percent of the cases the outsourcing involved active partner participation in product development activities — the highest number across all industries groups of the taxonomy. Long-term contracting is used across the board with an average of 65 percent using this type of arrangement. Regarding the performance of outsourcing activities, firms in science-based manufacturing seem to have performed better than other firm-types, as 31 percent indicated that the outsourced activity had performed better than expected.

The regression results try to go beyond these descriptive patterns and investigate the determinants of outsourcing success. In a nutshell, the results indicate that using the partner actively in developing products and services contributes significantly to increasing the likelihood that the partnership is successful. Besides, the study finds important similarity between services and manufacturing firms in that for both firm-types, the active involvement of partners appears to be key for offshore outsourcing activity success. Without being a direct test of alternative theories this finding provides support for the relational view of comparative advantage. The paper does also provide support for the idea that monitoring the quality of the delivered input is important to outsourcing success in this context, especially for manufacturing firms.

However, there are strong indications that long-term contracting has a negative effect for those that simultaneously use the partner actively in product development operations. This negative effect indeed overturns the positive effect of the product development partnership leading the paper to conclude that offshore outsourcing companies should use the partner actively in a product development sense, but that a long-term contract relationship will leave such relations ineffective, all else equal. When we are dealing with complex activities — such as those involving the development of new products and services — trying to use both long-term contracts and involving partners in development activities when the conditions are ever-changing, appears to be detrimental to offshore outsourcing success. Indeed, changes in the underlying products or services may also represent substantial changes in the partners' business process and therefore represent investments and restructuring of existing organizational processes. It is therefore possible that long-term contracting may leave much to desire in terms of inputs from the partner with respect to product and process innova-

tion, and that it is very difficult to construct a contract that is meaningful and at the same time provides enough flexibility to secure offshore outsourcing success.

An important management and policy implication of these findings is that Nordic firms and their managers need to invest heavily in their relationships to the offshore outsourcing partners located abroad in a low-cost country — an arms-length approach to outsourcing is very likely to fail in the sense that involving the partner actively in development processes and monitoring quality closely is more likely to give rise to perceived offshore outsourcing success. Moreover, firms' managers should be reluctant to use long-term contracts when they work closely with partners in developing new products, since it appears to be very difficult to get such contracts right. The reason for this may be that these contracts are not easy to specify in a sufficient flexible way so as to allow for changing the nature of the agreement when development projects change direction, due to the fact that product development projects inevitably involve uncertainty concerning the outcome and on how to solve problems along the way.

As pointed out by Lundvall and Borrás (1999), new broadly-defined better-practice organizational trajectories can perhaps be discerned and policy-makers could help management and workers to move ahead along these paths. This implies moving towards more horizontal communication, more intense communication inside and outside the firm, and delegating responsibility to the workers. Policy-makers can stimulate research in this area and help establish a forum for the exchange of experiences of organizations in this regard. Moreover, at various levels, external networking — including building relational links to outsourcing partners — may be crucial in order to stay ahead in the innovation race, given the rapid pace of change in the current economic environment, as geographically closed networks may possibly obstruct rather than encourage innovation. Therefore, innovation policy should attempt to support networking beyond the local and national environment of the focal firm.

The fourth paper in this phase of the project is the one by Karpaty, Kokko and Tingvall (2008). Similarly to Laursen, Reichstein and Maskell (2008) this paper also focuses on the offshoring internationalization channel, and provides new empirical evidence based on a very rich panel dataset of enterprises in manufacturing and service industries in Sweden. However, differently from the previous paper this work does not study the determinants of this internationalization channel but it rather investigates its impacts on innovation. The analysis of this feedback mechanism is an important task for this phase of the project: innovation is a major factor shaping internationalization

and international competitiveness, but the latter does in turn affect the innovation and R&D intensity of firms. It is therefore important to consider both sides of the innovation-internationalization link.

The debate about the possible consequences of offshoring in advanced countries clearly reveals that there are worries about its impacts. These concerns are mostly connected to a fear of job losses as firms move production abroad. While low-skilled workers are obviously the most vulnerable to the competition from offshoring, the latter poses a challenge also for other groups of workers. Hence, not only unskilled jobs but also ICT jobs and other knowledge intensive tasks requiring skilled labor – perhaps even R&D – may be at stake. Existing studies on offshoring and labor demand have mainly focused on detecting the expected shifts in demand from unskilled to skilled workers, whereas the effects on the composition of skilled labor and R&D in the home country have largely been ignored. This is unfortunate. R&D is one of the main determinants of firm competitiveness, and it is of prior interest to ask whether offshoring leads to a relocation of R&D from the home country to other foreign locations.

To shed some light on these questions, the paper uses highly disaggregated data from Swedish industry to decompose the relation between offshoring and labor demand in several ways. Firstly, the study distinguishes between several categories of labor, and examines whether offshoring affects the distribution of skilled labor between R&D and other advanced tasks. Secondly, it looks separately at the consequences of offshoring in the manufacturing and in the service sectors. Thirdly, the study distinguishes between service offshoring and material offshoring. Since offshored services are intangibles that typically cannot be stored, service offshoring may require closer commutation between the mother firm and the foreign subcontractor than what it is necessary for material offshoring.

The empirical analysis is based on a large panel dataset that stems from three register-based databases from Statistics Sweden. The financial statistics data set (FS) contains detailed information on all Swedish private sector firms with at least 50 employees. Examples of variables included are R&D, value added, capital stock (book value), number of employees, total wages, ownership, profits and sales. Second, the regional labor market statistics dataset (RAMS) includes labor data on all establishments for the period 1990-2005. RAMS is used to describe the labor force at the establishment level with respect to educational level and demographics. Finally, data on imports of materials are collected at the firm level by Statistics Sweden for all large firms for the shorter time period 1997-2007, and data on imports of

services are provided by the Swedish Central Bank and cover the period 1992-2002.

To analyze how offshoring affects labor demand and firm R&D, the paper carries out an econometric analysis of this panel dataset that explores effects on two (closely related) dependent variables. Firstly, on the basis of their educational attainment, labor is divided into two skill groups – lower secondary plus upper secondary and tertiary education. These groups are used to define the first dependent variable. Secondly, because of the lack of information on the wage cost of R&D-workers, the ratio of R&D to total wage costs is used as a proxy for the proportion of the labor force allocated to R&D. Offshoring can influence the demand for skilled labor either toward job tasks such as information, marketing, and accounting, or towards R&D. Using the ratio of R&D-expenditures to total wage cost for skilled labor as a dependent variable, we hope to detect shifts in the relative demand for the two categories of skilled labor.

In line with the other papers presented in this project, the sectoral distribution of offshoring firms across two-digit industries in Sweden shows large heterogeneity. The largest share of offshorers is found in the manufacturing branch, whereas in services the highest share is in physical infrastructure service industries (e.g. retail trade). Unsurprisingly, offshoring is less common in sectors like for instance hotels and restaurants and storage, i.e. for firms operating in non-tradable sectors.

The econometric analysis then explicitly investigates the extent to which offshoring has an impact on firms R&D and innovation by determining a reallocation of labour among different skill workers group. The main result is that offshoring typically shifts firm's relative labor demand from less skilled to skilled workers in both the manufacturing and the service sectors. Offshoring may also raise the domestic firms' R&D intensity. Interestingly, this R&D enhancing effect is only found for the services industries, whereas the estimations do not find any significant effects for international relocation of R&D in the manufacturing branch. The fact that advanced operations like R&D are not offshored is indeed consistent with previous empirical evidence, and it is also in line with theoretical work suggesting that the contract cost increase with the complexity of the outsourced activity (see also theoretical discussion in the paper by Laursen, Reichstein and Maskell, 2008).

However, the positive effects of offshoring on skilled labor demand turn out to be different in the two branches of the economy. Offshoring of goods has a positive effect on the demand for skilled labor in the manufacturing sector, while the corresponding effect in the ser-

vices sector is confined to the offshoring of services activities. A closer look at offshoring and firms with different R&D intensities confirms that offshoring is not a reason to reduce the demand for neither skilled labor nor R&D among the most R&D-intensive firms. Instead, among these firms the paper finds offshoring to be associated with a concentration of R&D at the domestic market. This applies for the services sectors, and for both material offshoring and service offshoring. Firms with lower initial R&D intensities, by contrast, tend to see a falling demand for skilled labor (but not R&D) as a result of services offshoring. Since these firms are typically less sophisticated than the most R&D-intensive firms, the results suggest that offshoring may be used as a tool for outsourcing simple development tasks. More qualified R&D, undertaken by the more R&D-intensive firms, tends to stay in the domestic market.

3. Conclusions

The ICONS project has investigated the relationship between innovation and the international competitiveness of service industries. The various empirical studies produced within the project have made use of a rich variety of data sources on the innovative activities and international performance of thousands enterprises in both manufacturing and service industries in the Nordic countries, and complement these with data at a more aggregate (industry- and country-) level of analysis.

In order to shed new light on this engaging, broad and complex field of research, the project has aimed at three more specific (and interrelated) objectives: (1) the investigation of differences across industries in terms of their technological activities and economic dynamics, in order to highlight the main drivers of the process of structural change and industrial transformation in the long run; (2) the analysis of the link between innovation and economic performance at the firm-level, and of the extent to which this relationship is affected by sector-specific characteristics related to technological and market conditions specific to each industry; (3) the study of the patterns and determinants of different internationalisation channels and strategies that are undertaken by Nordic enterprises in the service sectors.

These three objectives have been considered by the various empirical papers included in the three parts of the project. While the previous section has presented in quite some details the main results of each of these papers and the main policy implications that may be drawn from them, this concluding section will provide a more synthetic summary of the overall results and contributions of the project, as well as the related implications in terms of research and innovation policy. We will highlight eight main points and briefly discuss them as follows.

A broad theoretical model of innovation and competitiveness

The existing literature on innovation and international competitiveness is extensive though quite fragmented. Various branches of empirical research have focused on different aspects of this general relationship. In particular, one important issue refers to the link between innovation and productivity, which represents one relevant precondition to compete in the international arena. Another issue refers to the different internationalisation channels adopted by firms, and how these are shaped and affected by innovative activities and strategies.

Recognizing the complexity and broad scope of the innovation-competitiveness link, the ICONS project has focused on different facets of this relationship, and adopted an open theoretical framework that emphasizes the importance of taking into account a variety of contextual factors, such as in particular sectoral technological regimes, competition and market conditions, the type and quality of vertical and external linkages and, more in general, the functioning and characteristics of national systems of innovation. The adoption of such a broad and open type of approach represents a useful foundation for the policy-making process, as any policy action targeted at one part of the system may have important feedback effects on other aspects, thus possibly leading to the generation of cumulative mechanism (e.g. a self-reinforcing two-way relationship between innovation intensity and internationalisation ability).

Firm-level data sharpen the empirical analysis of innovation and competitiveness

The availability of firm-level data on innovation has substantially increased in recent years, and new datasets such as those from the *Community Innovation Surveys* in Europe have greatly sharpened the understanding of the relationship between innovation and economic performance in both manufacturing and service industries. Data availability is however still more limited with respect to the analysis of internationalisation activities, since there are rich available datasets for various countries on some of the channels of internationalisation (export and FDI) but not for others (e.g. offshoring and R&D outsourcing). The ICONS project has been motivated by the usefulness of enterprise-level information, and its contribution to the microeconomic literature on innovation and international performance is twofold.

First, besides using existing large sets of data that comprise a rich variety of information on thousands of enterprises in the Nordic countries (e.g. CIS2 to CIS5), the project has also presented new empirical evidence on the internationalisation activities of Nordic service providers by presenting the results of two new survey data collection, one for Norway (Castellacci, 2008d) and one for Denmark (Laursen, Reichstein and Maskell, 2008). Secondly, in order to exploit these data in an appropriate manner, most of the papers produced for the project have made careful use of state-of-the-art quantitative methods of analysis. These methods have in particular taken into account, when data availability has made this possible, two of the major statistical issues that are often discussed in the current microeconomic literature in the field: the selection-bias problem often arising in the context of survey data, and the endogeneity issue caused by the important feedback mechanisms in the innovation-competitiveness link (see discussion in Castellacci and Zheng, 2008).

These two contributions of the ICONS project with relation to firm-level data and their analysis lead to a reflection that is relevant for policy. It is clear that enterprise-level information is crucial to sharpen our understanding of innovation, internationalisation and economic performance. However, the quality of firm-level data and their availability for research purposes should be enhanced even further. A proper analysis of the dynamic nature of this phenomenon would admittedly require a more frequent use of panel data analysis, and this would in turn necessitate a greater availability of this type of information (currently available only in a few countries) and a more rigorous standardization of survey questionnaires over time.

The relevance of different levels of analysis and of the interactions among them

The focus on firm-level analysis that has attracted the attention of applied scholars in the last few years should however not draw away attention from the systemic and multilevel nature of the economic and innovation system. In the existing literature, various branches have mostly focused on different levels of analysis (firms, industries, countries) and frequently neglected the existence of important interactions and feedback mechanisms between these distinct levels. For instance, the competitiveness of an industry is greatly shaped by the performance of the enterprises belonging to that sector, and the latter, in turn, is strongly affected by a large set of industry-specific conditions. The same may be said with respect to the two-way relationship and co-evolution process linking together the performance of industrial sectors and the dynamics of a national system (Castellacci, 2008e). This multilevel perspective provides an interesting avenue for future research.

While the ICONS project has not tried to investigate explicitly the various channels of interactions between different levels of analysis, the research carried out within the project has however implicitly adopted a multilevel perspective by investigating the innovation-competitiveness relationship at different levels of analysis, i.e. enterprises, industrial sectors and national systems. Besides opening up a new direction for future research, such a broad approach does also have an important implication for policy. Since policy actions targeted at one level of analysis may have feedback effects on other levels as well, there is a need for a greater coordination among different policy levels, so that firm-level innovation policy schemes, industrial policies and more general actions to enhance the national innovation system should be well coordinated and consistent with each other.

An integrated framework encompassing both manufacturing and service industries

The service innovation literature is rapidly flourishing but, quite unfortunately, it seems to be developing as a separate branch of analysis without much relationship to, and interaction with, the well-established literature on innovation in manufacturing. There is in the existing literature a widespread feeling that a greater integration between these two related branches of research would be greatly beneficial, since manufacturing and services represent closely intertwined parts of the economic system and the relationships and knowledge exchanges between them are becoming increasingly important.

Motivated by this research gap in the field, the ICONS project has developed a theoretical model that combines manufacturing and service industries within the same conceptual framework, and then used this model to empirically analyse innovative patterns and competitiveness performance of firms and industries in the Nordic economies. In a nutshell, the results of the analysis of this integrated model lend support to the idea that the relationship between innovation and competitiveness does not substantially differ if we compare the manufacturing to the service branch of the economy. The real difference emerges when we further differentiate manufacturing and services into distinct sub-groups of industries, in the sense that there are groups of industries (both within manufacturing and within services) whose innovative activities and internationalisation strategies are well distinct from each other (see next point).

The adoption of this comprehensive approach linking together manufacturing and service innovation represents an important direction for future research. While recognizing the existence of interesting peculiarities in the innovation process in the service industries, these specificities should not be over-emphasized, and their study should indeed be approached within a broader framework looking at the whole innovation system, rather than just a subset of industries. This conclusion is important for academic research as well as for the policy making process, which should to the extent possible adopt a set of comprehensive strategies targeting the interactions between manufacturing and services, rather than just focusing on the specificities of each of these branches.

The relevance of sector-specific conditions

Industry-specific characteristics, related to the technological and economic environment in each industrial sector, provide an important set of opportunities and constraints to the innovative activities carried out by private firms in the economy. While this is by now a well established proposition in the innovation literature, empirical and econo-

metric studies in the field do still find it hard to deal with this aspect in an appropriate and convincing way (and the common use of sector dummies in econometric studies of the innovation-performance link does not really provide any clear insight on the nature and extent of cross-sectoral differences).

One of the main endeavours of the ICONS project has been to emphasize the relevance of sector-specific conditions and study the extent to which they shape the relationship between innovation and international competitiveness in the Nordic economies. The first part of the project has developed a conceptual typology of manufacturing and service sectors that points out the specific characteristics of distinct industry groups in terms of their innovative capability and internationalisation propensity (Castellacci, 2008b and 2008d). In the second and third parts of the project, the various empirical studies have then carefully studied this aspect and pointed out that the impact of innovation on productivity and on the process of internationalisation of firms is highly sector-specific. Besides uncovering the existence of aggregate (average) relationships, these empirical papers have also shown the great variety of sectoral patterns that characterize the innovation-competitiveness relationship.

The general policy implication that these results lead to formulate is the need to adopt a policy strategy where sectoral specificities are indeed taken into due consideration. In particular, the widely spread policy focus on R&D targets and innovation incentives may work well for some of the R&D intensive sectors, but it may arguably be less effective to stimulate technological activities in industries where the innovative mode is less characterized by formal R&D activities and more oriented, for instance, to the acquisition of technologies from advanced suppliers or on non-technological (e.g. organizational) innovation. In short, innovation policy must be targeted to the specific set of opportunities and constraints that characterize innovative and international activities in different industries of the economy.

Competitive advantages and the dynamics of national systems in the long run

An interesting debate in the academic literature in the fields of economic growth and trade theories refers to the role of industrial sectors for the overall dynamics of an economic system in the long run. Put it simply, a traditional approach would suggest each country to specialize in those industries where it already has *comparative advantages* (e.g. linked to the existence of natural resources), whereas a different tradition closer to the innovation literature emphasizes the importance of building up *competitive advantages* in the most progressive (technologically advanced) industries of a given historical age.

The taxonomic model developed in the first part of the ICONS project has developed a conceptual model and provided empirical evidence to reassess this engaging debate, and the results lend support to the latter position. The taxonomic model shows that industrial sectors that are closer to the core of new and emerging general-purpose technologies (GPTs) are characterized by higher technological opportunities and a more dynamic economic performance in the long run. When we analyse the Nordic economies within the broader international perspective and in a long run framework, industrial groups such as science-based manufacturing and network infrastructure services do in particular show a great dynamism and a strong impact on the overall performance of national systems in advanced countries in the last few decades. Innovation and industrial policies oriented towards the building up of new competitive advantages in technologically advanced industries are sometimes criticized and referred to as *high-tech biased*. While acknowledging the importance of specific policy actions in support of more traditional and low-tech sectors as well, our results do indeed show the importance of focusing on high-opportunity industries, which constitute the bulk of the current growth potential and whose dynamism may have last-longing and pervasive effects on many other upstream and downstream industries of the economy.

Technological regimes and market conditions affect innovation and competitiveness

The microeconomic literature studying the impacts of innovation on the productivity dynamics and international performance of enterprises is large and has recently attracted increasing attention due to the greater availability of firm-level data. One specific aspect that has not been sufficiently dealt with in previous studies relates to the role of sector-specific conditions in terms of technological regimes, industrial dynamics and the competition patterns that characterize different industrial sectors. The second part of the ICONS project has investigated this issue by analysing the extent to which market structure and industrial dynamics conditions shape the innovative activities and productivity dynamics in a broad range of manufacturing and service industries.

The results point to the importance of industry-specific technological regimes in affecting firms dynamics, and indicate, more precisely, that the relation between competition and innovation is characterized by an inverse U-shaped relationship (Aghion et al., 2005; Tingvall and Karpaty, 2008). That is to say, when competition is not too strong (say, in a monopolistic or oligopolistic market), policies that increase competition tend to have a beneficial effect on innovation (instead of hampering it as a substantial part of the older literature had previously ar-

gued). Competition policy is therefore crucial to innovation and it may therefore be important to sustain the competitiveness and the dynamics of industrial sectors. Its relevance to innovation would therefore suggest the need for a greater coordination between competition and innovation policy strategies.

Systemicness is an important driver of innovation and competitiveness

The literature that deals specifically with the internationalisation strategies of firms and their possible determinants is also large. As previously observed, however, this literature is quite fragmented in that various branches of empirical research have so far focused on different, though, related internationalisation channels, first and foremost export and FDI. Much less is known about other increasingly important international activities such as overseas collaborations, offshoring and R&D outsourcing. Besides, most of the previous literature in the field has commonly focused on manufacturing industries and frequently neglected the service sectors.

The third part of the ICONS project has tried to contribute to these research gaps by providing new empirical evidence on the internationalisation strategies of Nordic service providers, and by investigating the patterns and determinants of different interrelated channels rather than focusing on just one or two of them. The results of the empirical papers contained in this part of the project provide interesting indications and suggest novel directions for future research.

First, the results suggest that firms may find it convenient to adopt different internationalisation strategies rather than relying on only one of them. Different internationalisation channels may therefore be complement, rather than substitute, strategies for enterprises who seek to compete in the international arena. For instance, firms in the group of knowledge intensive business services are on average active in terms of a variety of channels, and in particular exports, FDI, international cooperations and R&D outsourcing. The complementarities among different internationalisation strategies may also be reinforced by the fact that any given internationalisation strategy may have an indirect enhancing effect on the other channels by increasing R&D and the innovative intensity of firms. This is for instance what suggested by the paper of Karpaty, Kokko and Tingvall (2008), where it is shown that offshoring has a positive effect on R&D and innovative activities of Swedish firms – and this does of course have a feedback effect on their ability to compete in international markets.

Secondly, the results indicate that one important driver of internationalisation and a key factor of success in overseas markets is represented

by the intensity and quality of vertical linkages, i.e. the type of partnership or commercial relationship that a firm active in international markets is able to establish with its foreign counterparts, be they suppliers, competitors or advanced users. In particular, the two papers by Castellacci (2008d) and Laursen, Reichstein and Maskell (2008), presenting new empirical evidence for Norwegian and Danish firms respectively, indicate that the quality of the relation with foreign partners is a key factor of success for outsourcing activities, and that firms are more propense to engage in international partnerships when geographical and cultural proximity facilitates the commercial interaction and knowledge exchange. Further, Laursen (2008) corroborates the findings of previous studies and points out the importance of user-producer interactions for the dynamics of exports of Danish firms.

Taken together, these results confirm the relevance of a systemic and relational view, which implies that the main policy focus should not simply be to foster the capability and innovative intensity of individual actors in the innovation system, but rather to strengthen the connectivity and systemicness by enhancing the intensity and quality of vertical linkages.

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5. Papers produced for the project

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(1) Castellacci, F. (2008a): “Innovation and the competitiveness of industries: Comparing the mainstream and the evolutionary approaches”, *Technological Forecasting and Social Change*, 75 (2008): 984-1006.

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(4) Castellacci, F. (2008d): “The internationalization of service industries: Evidence from a survey of Norwegian firms” *NUPI Working Paper 753*. The revised version is currently under review for *Technological Forecasting and Social Change*.

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(6) Gustavsson Tingvall, P. and Karpaty, P. (2008): “Service sector competition, innovation and R&D”, Stockholm School of Economics, 2008.

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