Faculté des Sciences Économiques et Sociales

École doctorale SESAM - Laboratoire Clersé

Thèse de doctorat

en

SCIENCES ÉCONOMIQUES

PUBLIC-PRIVATE INNOVATION NETWORKS IN SERVICES

Présentée et soutenue publiquement par

Rabeh MORRAR

Le 27 Juin 2011

Jury :

Damien Broussolle, Maître de conférences-HDR, Institut d'Etudes Politiques de Strasbourg, Rapporteur

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بسم الله الرحمن الرحيم

{قُلْ هَلْ يَسْتَوِي الَّذِينَ يَعْلَمُونَ وَالَّذِينَ لَا يَعْلَمُونَ}

Dis: ‹ Sont-ils égaux, ceux qui savent et ceux qui ne savent pas? ›

صدق الله العظيم

To my parents

To Palestine, the place of inspiration

Acknowledgments

This work is the culmination of a learning and transformation process that was only possible due to the help, guidance, advice, support and love of many people.

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General Introduction

Innovation is a key driver for enhancing economic growth and welfare in modern economies. Thus, economic policies highly emphasize this important relationship between innovation and economic performance, and this is clearly realized through the implementation of relevant strategies proposed to achieve market competitiveness and the maximum economic impact of innovation.

Since Schumpeter's seminal contribution in 1934 (Schumpeter, 1934) to recent period, scholars have mainly discussed the concept of innovation from the viewpoint of the industrial sector. They very often ignored innovation in services and the possibility of its positive impact on economic performance. This is explained by the traditional view of services as a low productive, low capital intensive and weak competitive sector, compared to the innovative and performance enhancing in manufacturing sector. Since the beginning of 1990s, the industrial bias of innovation studies has started to change as service activities reached nearly 70% of the economic activity in developed countries, and private and public services accounted for almost two thirds of jobs in most of the OECD countries. Therefore, the unawareness of innovation in services is inconsistent with the role of services in macroeconomics aggregates. The importance of services and innovation in services is emphasized by the European Commission. "For Europe to compete effectively and generate the growth it requires for sustained social and economic development, it needs a healthy and an innovative service sector.

No longer can Europe afford to neglect services and its innovative potential in policy terms" (Expert Group on Innovation in Services, 2007).

During the last 20 years, a reduced number of scholars have entered the black box of innovation in services and have provided new analytical perspectives for addressing its specificities (Soete and Miozzo, 1989; Gallouj, 1994, 1998, 2002; Gallouj and Weinstein 1997; Djellal and Gallouj, 1999, 2005, 2008a, 2008b; Howells, 2000, 2006; Miozzo and Soete 2001; Miles 2002, 2005; Bryson and Monnoyer, 2004; Tether, 2005; Monnoyer, 2010). The nature of innovation in services and its dynamics are still underestimated topics. This leads to crucial problems related to the correct estimation of innovation activities and economic effect of innovation for many service sectors. The specific nature of service outputs (i.e. its immateriality, co-production, heterogeneity, inseparability) is likely to explain these problems.

Economic performance requires specific policies that seek to further encourage and exploit the innovative potentials of service sectors. Traditional innovation policies (e.g. high expenditures on R&D activities, public support for complex and technological innovation activities and using of patents and industrial design as innovation protection policy) that are efficiently applied to manufacturing sector might not be efficient for services. This is particularly levied to the specific nature of innovation in services.

It is generally accepted that the innovation activities cannot be limited to the boundary of the firm. Interaction with surrounding environment (other firms, public institutions, individuals, etc) is essential for a successful and efficient innovation process. Thus, in the last 20 years, the mobilization of an interactive or non-linear approach (e.g. cooperation, innovation systems, innovation networks and innovation clusters) is acknowledged to be the most important innovation strategy that is applied successfully to access for complementary knowledge and technological resources from out of organization's boundary in order to produce new innovation outputs in manufacturing sector (Freeman 1987; Lundvall 1992; Grabher 1993; Camagni 1991; Edquist 1997;

Manley 2002; Eickelpasch et al. 2002; Bross and Zenker, 1998). Cooperation between private firms and public organizations like universities and public research centers is considered to be a prominent form of cooperation mobilizing in order to produce material artifacts (technological innovations) in manufacturing sector. These cooperation frameworks may be labeled "TechPPINs" (technological public-private innovation networks).

Compared to manufacturing, cooperation frameworks for innovation in services are notcommonlywell-known. This might be associated with the long period of ignorance of the question of innovation in services in the literature and more importantly to the traditional idea that collaboration between organizations or innovation networks involves complex knowledge and R&D activities, whereas the innovation in service organizations is not supposed to be based on complex knowledge and R&D activities.

However, in service sectors, the development of innovations also requires new cognitive resources wherethese cognitive resources differ depending on the knowledge or the basis technological nature of innovation output. In this respect, non-technological innovation is not based (mainly) on S-T knowledge but rather on more soft knowledge (HSS, organizational engineering, human skills, etc).

Recently, due to major economic and technological changes (rapid globalization- spurred by the high development of telecommunication- convergence of consumer preferences, new technological paradigms stemming from advances in information and communication technologies (ICTs), shortening the life-cycle of service outputs, and the dependence of many service innovations on high skills human capital), local connections hampered the organizations' abilities to reformulate their competitive skills, provide solely the knowledge resources and competences required to keep pace with their innovation activities. Thus, external connections through collaboration relationships and INs are likely to be a successful strategy to obtain complement cognitive resources and enhance innovation in services. In other words, service organizations shift from a traditional perspective to a more system-centered approach of innovation (non-linear model of innovation), such that innovation processes are "systemic, complex, multi-level, multi-temporal and employ a plurality of heterogeneous economic agents" (Lundvall 1988; 1992, Freeman 1988; Nelson 1988; 1993; Rossi et al. 2009).

Services may be provided either by public sectors (e.g. health and public administration services) or by private sectors (knowledge intensive business services, hotels and restaurants and retail trade for example). The innovation issue is, therefore, still addressed within each sector separately. Such an approach underestimates the cooperation between public and private actors i.e. public-private innovation networks in services (ServPPINs).

ServPPINs are rarely discussed, neither in theoretical nor in empirical literature. In this work, we focus on this unexplored issue i.e. on the nature and dynamics of ServPPINs from both a theoretical and empirical perspectives. Within this general goal, the most important questions addressed are the following ones: Why are services important to test the cooperation strategy? How do they differ from manufacturing sectors? Are the technological (traditional) INs or PPINs an efficient tool to explain innovation in ServPPINs and how should they be amended for innovation in services? How to construct a conceptual framework which can explain the innovation processes in ServPPINs? Why is it important to consider ServPPINs as dynamic structures? What are the cognitive synergies that public and private actors can mobilize through collaboration in ServPPINs, and how do they differ from economic synergies in public-private partnerships (PPPs)? How does the nature of innovation determine the mode of public and private actors involved and the structure of ServPPINs? How to adapt the innovation mechanism in ServPPINs depending on the type of innovation output produced (technological or/and non-technological)? What is the expected effect of cooperation in ServPPINs on innovation output?

In order to try to find answers to these questions, this work is divided into three main parts. The first part includes a review of the debate about innovation in services and an empirical work that explores the innovation behavior and economic performance of innovation in service sectors compared with that in manufacturing sector. This is based on data from the fourth community innovation survey (CIS4) in France. The second part includes a discussion about two types of the PPINs: technological or traditional PPINs (TechPPINs) and PPINs built for producing innovation in services (ServPPINs). Highlighting TechPPINs is important to shed the light on the innovation mechanisms and the main roles of network actors in, and on how they vary when the production of service innovations is the main objective of collaboration. A conceptual framework is designed which describes the mechanism of innovation in each type of PPIN. The third part is devoted to two empirical applications of the framework to the PPINs in service sector. The first application is a case study, in which we illustrate how the conceptual framework is applied to a real PPIN in health sector called "Lyonbiopole". The second application consists of an empirical work that estimates the relationship between cooperation for innovation and innovation output in the French service sector using data from the CIS4.

Part 1: Innovation in services from a theoretical and empirical perspective

Introduction

The first part of the thesis is devoted to the question of innovation in services.A comprehensive survey of the literature is provided using the assimilation-differentiation-integration framework (Gallouj, 1994). This review is followed by an empirical work on the innovation in the French service sector compared with manufacturing sector. The empirical work is based on the French CIS4 data in comparison with that in manufacturing sector.

To clearly understand what innovation in services is (which is the purpose of this part at both the theoretical and empirical levels) is very important for the analysis of ServPPINs which is our main goal. This first part is organized into two chapters.

The first chapter consists of a survey of the literature on innovation in services that has been developed in the last 20 years. It includes a discussion of the nature of innovation in services and of the various existing conceptual perspectives for innovation in services. It also addresses the differences between innovation in services and innovation in manufacturing sector. This survey emphasizes the importance of cooperation as an efficient innovation strategy for services. The survey is also important to understand the characteristics of innovation in service sectors, which are likely to facilitate the construction of a conceptual framework for public-private innovation networks in services (ServPPINs).

The second addresses the question of innovation in services empirically. In this course, two important issues are discussed. The first is a comparison between service and manufacturing regarding innovation behavior using large set of innovation indicators which describes different specificities related to innovation in services (e.g. innovation output, innovation input, innovation expenditure, source of information, protection of innovation, etc). The second is the estimation of the relationship between innovation and economic performance in both service and manufacturing sectors. This enables us to discuss whether services and service innovations are the new engine for economic growth.

Chapter 1: Innovation in services: a survey of the literature

Introduction

The awareness of the importance of service innovation as an engine for the economic growth has started since the beginning of the 1990s. Before that period, services were considered as non-innovative activities or as subordinate activities only adopting technologies (mainly the ICTs) developed in the manufacturing sector. The innovation literature was focused on the manufacturing sector, technological product and process innovation. Innovation in services was addressed within a manufacturing based perspective. The corresponding literature "assimilated services within the consolidated framework used for manufacturing sectors and manufactured products" (Gallouj and Savona, 2009). This bias towards manufacturing might lead to the underestimation of innovation in services and its effects.

Since the beginning of 1990s, things have started to change, mainly because the underestimation of the dynamics of the service sector was seen as inconsistent with the rise of the service economy, nearly 70% of GDP and employment in all developed countries. This means that the discussion about innovation in services should be extended beyond the traditional (technological) perception.

A certain number of studies (Gallouj, 1994, 1998, 2002; Gallouj and Weinstein 1997; Sundbo, 1998; Sundbo and Gallouj, 1999; Djellal and Gallouj, 1999; Djellal, 2000, 2002; Hill, 1999; Miles 2002, 2005; Tether, 2003, 2005; Howells, 2006; Philippe and Leo, 2010; Monnoyer, 2010) have been conducted, aiming to shed the light on the specificities of innovation in services beyond the traditional biased point of view which constrained it to the adoption and use of technology. These studies take into account the main characteristics of the service product (its intangibility, co-production and co-terminality) which makes it efficient to define innovation in services.

The objective of this chapter is to provide a survey of innovation debate in services. Section 1 discusses the characteristics of services which are important for defining and measuring innovation in services. Section 2 provides a discussion of the main theoretical perspective mobilized in the literature in order to account for innovation in services. It addresses the main theoretical inferences associated with each perspective accompanied with a survey of the most important pertinent application in each perspective. In section3, we discuss the relationship between innovation in services and some indicators of economic performance like productivity and employment.

1. Services: their definition and specificities

The specificities of the service output have largely been neglected by the innovation literature. Scholars have merely applied to services analytical tools designed for manufacturing within the traditional technological view of innovation. This has led to the misunderstanding and the underestimation of innovation activities in services. It has also led to the wrong conclusion stating that innovation in services has relatively a low effect on economic performance (productivity and value added), compared to innovation in manufacturing.

Therefore, a clear definition of the service activity and its characteristics is a key factor for the correct measuring of innovation output in services and the estimation of its real economic effect.

1.1. The definition of service concept

"The study of services innovation immediately poses the question of how a 'service' should be defined" (DTI, 2007). Because of its fuzzy nature or intangibility, its heterogeneity and unstable character, the service output is difficult to define (Djellal and Gallouj, 2008a), and so it is also difficult to measure its output[1] and productivity (Melvin, 1995).

Hills (1977) defined a service as "a change in the condition of a person, or a good belonging to some economic unit, which is brought about as a result of the activity of some other economic unit, with the prior agreement of the former person or economic unit". Gadrey (1996; 2000) expanded Hill's definition putting forward what is known as the "service triangle": "a service activity is an operation intended to bring about a change of state in a reality **C** that is owned or used by consumer **B**, the change being effected by service provider **A** at the request of **B**, and in many cases in collaboration with him / her, but without leading to the production of a good that can circulate in the economy independently of medium **C**". In other words, Gadrey introduced services as a process or a set of processing operations which are implemented through interactions (intervention of **B** on **C**, intervention of **A** on **C** and service relations or interactions) between three main elements: service provider, client and a reality to be transformed. The medium **C** in Gadrey's definition may be material objects (M), information (I), knowledge (K) or individuals (R). An important point in Gadrey's definition compared to Hill's one is that the output cannot circulate economically and independently from **C**.

Based on the medium elements, the service provision is associated with four groups of processing operations or problem solving functions (Gadrey, 1991; Gallouj, 1999, Djellal et al. 2003 and Djellal and Gallouj, 2005): 1) Tangible (material transformation) operations and functions (M). 2) Informational operation and functions (I) which both involve the usual scientific and technological knowledge. 3) Cognitive or methodological operations (K) and 4) the contractual or relational service operations (R). This functional or operational definition is used as a framework to

[1] The service production is an action, a treatment protocol, which leads to a change of state not the creation of tangible good (Gallouj, 1998).

define service output in assembled service activities. For example, Djellal and Gallouj (2005) used it for analyzing hospital output.

Inspired by Lancaster (1966) and Saviotti and Metcalfe (1984), Gallouj and Weinstein (1997) a conceptual framework was developed for the provision of products (goods and services) that describe service output in terms of a set of characteristics and competences, which reflects both internal structure of product and external properties. The delivery of services in this framework depends on the simultaneous mobilization of competences (from service provider and clients) and (tangible or intangible) technical characteristics. In a more detailed description, the service provision may require the interactions between four main vectors: service provider competencies [C], consumers' competencies [C*], tangible and intangible technical characteristics [T] and finally the vector of characteristics of final service output [Y]. This framework has been used in a large extent to define innovation in service, within the synthesis approach (see section 2.3). The innovation can be defined as "the changes affecting one or moreelements of one or more vectors of characteristics (both technical and service)or of competences. These changes are intended to be defined by one ormore basic mechanisms: evolution or variation, exit or entry of one or moreelements; and association, dissociation or formatting of one or more elements" (Gallouj and Savona, 2009).

1.2. The specificities of services

In manufacturing the innovation is mainly embedded in two main changes: one is a change in final products (goods) which is described as product innovation, and the other is a change in the way products are created or delivered which is described by process innovation. The dichotomy (classification) is not easy to apply to service innovations. This is due to a certain number of service specificities which are discussed in the literature (Miles, 1993; Sirilli and Evangelista, 1998; and Hipp et al. 2000).

1. Co-terminality between production and consumption

Co-terminality (co-production) in service production involves the close interaction between production and consumption (Hill, 1999), or simultaneity between service production and consumption. Services are consumed as they are produced. Co-terminality makes the dividing line between product and process innovation blurred (Bitran and Pedrosa, 1998). It highlights the role of clients in service innovation. The client plays an important role in the development of new services (Kline and Rosenberg, 1986; Broussolle, 1996 and De Brentani, 2001). In any service innovations, feedback provided through the consumers of services is an important source of incremental service innovations (Riedl et al., 2008). In manufacturing, conversely the clients are independent of the production process. They are just users of final products, and they do not participate in the production and delivery of the products.

2. High information intensity or intangibility of service products

Service products and processes are characterized by a fuzzy and high information-intangible nature. This means that they are not embedded in material or physical structures. They are "a process, a sequence of operations, a formula, a protocol, a problem solution" (Gallouj and Savona, 2009). Intangibility also confirms the importance of information technology as a key role in innovation activities in services (Sirilli and Evangelista, 1998). Intangibility of service products may lead to some problems in the measuring of service output (Broussolle, 2003). A certain number of scholars (Gallouj and Weinstein, 1997; Windrum and Garcia-Goni, 2008) tried to solve the ill-defined nature of service output by developing a new approach that is applicable to both tangible and intangible products. This integrative approach will be addressed in section 2.3 below.

3. Low levels of capital equipment

Technological competences and physical capital play a major role in the production of industrial goods, but they are considered to be less consistent with fuzzy or immaterial output like in services. Service firms are considered to be rather highly dependent on competences embedded in human capital as key competitive factor and strategic element in organization and delivery of service products (Sirilli and Evangelista, 1998). This means that service may need special innovation which is not dependent on physical artifacts or complex technological changes (formalized R&D) modes in which training activities and organizational changes are central dimensions of the innovation process (Castellacci, 2006).

2. Conceptual perspectives for innovation in services

Service innovation studies have tried to go beyond the manufacturing-based perspective (see Gallouj, 1994, 1998, 2002; Gallouj and Weinstein 1997; Miles, 2002, 2005). They have sought to address the peculiarities of service activities in terms of innovation. In this view, the service-based approach (Gallouj, 1994) and integrative approach (Gallouj and Weinstein, 1997) are considered two prominent conceptualization frameworks that extend beyond the traditional perspective (assimilation approach).

2.1. Assimilation approach (traditional approach)

In the assimilation approach, innovation in services is perceived as fundamentally similar to innovation in manufacturing. This traditional approach for innovation in services only considers technological or visible modes of product and process innovation. It ignores other non-technological or invisible modes of innovation which are likely to include several types of innovation like "social innovations, organizational innovations, methodological innovations, marketing innovations,innovations involving intangible products or processes, etc." (Djellal and Gallouj, 2010b).Therefore, this assimilation approach underestimates innovation in service activities which is characterized by its intangible (invisible) and information-based nature.

The theoretical and empirical works favoring an assimilation approach are the most numerous. Within this perspective, Barras reverse product life cycle (Barras, 1986, 1990) is one of the most prominent works devoted to the adoption of the ICTs in service activities and their consequences on innovation. The reverse product life cycle, in contrast to the traditional product life cycle model (Abernathy and Utterback, 1975, 1978), starts with the introduction of incremental process innovations which aim to improve the efficiency of service produced. In the second phase, more radical process innovations are implemented to improve the quality of services. In the final phase, new product innovations are produced.

Another important illustration of the assimilation approach is provided by the construction of new evolutionary taxonomies for innovation in services, which emphasize different trajectories for different groups of activities according to their technological intensive aspect (Soete and Miozzo, 1989; Miozzo and Soete 2001; Evangelista, 2000). Miozzo and Soete's taxonomy (1989) distinguish the following trajectories: supplier-dominated, scale-intensive, science-based, information intensive or specialized suppliers.

Innovation systems and networks (Lundvall, 1992; and Nelson, 1993; Edquist 1997; Manely, 2002) are also other important concepts for discussing the innovation activities in an interactive and dynamic process. These innovation networks belong also to a technological biased notion when they address service innovation.

Compared to theoretical contributions, the empirical works using an assimilation perspective are very numerous. They mainly discuss the effect of the adoption of new technologies on economic variables (employment, productivity, etc) of service organizations (Miles et al., 1995; Antonelli, 1999; Andersen et al., 2000; Miles and Tomlison, 2000).

2.2. Demarcation approach

The demarcation approach considers that it is inappropriate to study the service innovation activities by only mobilizing conceptual and empirical tools that are mainly developed for technical-based activities (R&D, patents, and accumulation of capital). In Gallouj and Savona's natural life cycle of theoretical concern, assimilation approach represents the maturity phase.

The demarcation perspective seeks to consider any specific characteristics of the nature and modes of organization of innovation in services (Gallouj and Savona, 2009), and it emphasizes the importance of service trajectories taking into account the characteristics of service output (immateriality, interactivity, and co-production. It focuses on non-technological (service-based) and invisible innovation output (for example, customization of the services, problem solving, new solutions, new methods, and organizational structures). These innovation activities contribute to the economic development.

The demarcation approach leads to the production of new typologies for innovation in services (innovation indicators dedicated to services that include non-technological types of innovation such organizational innovation, ad-hoc innovation and marketing innovation. For example, Gadrey and Gallouj (1998) developed a new topology for consultancy that breaks down the product/process technological taxonomy for service innovation and includes three service specific types of innovation; ad-hoc innovation, new-expertise field of innovation and formalization innovation. McCabe (2000) has focused on organizational innovation (e.g. work organizations standardized methods of management control) in financial services. In similar work, Van der Aa and Elfring (2002) developed a taxonomy of three modes of organization innovation: multi-unit organizations, new combinations of services and customer as co-producer.

Local and global innovation survey (like, community innovation survey) in many countries are developed or restructured to incorporate the new service-based innovation typologies. This leads to new service-specific innovation data that opens a new wave of empirical testing for service innovation activities, and measuring innovation mainly in service sub-sectors which were considered non-innovative within the assimilation approach.

2.3. An integrative or synthesizing approach

The integrative approach aggregates both assimilation and demarcation approaches within a common conceptual framework that enlarges the view of innovation. This new perspective encompasses both services and goods and technological and non-technological modes of innovation (Gallouj and Savona, 2009; Gallouj and Windrum 2009). It represents the emerging and expanding phase of the natural life cycle of theoretical development in the service innovation discussion. The most important contribution in the integrative approach is provided by Gallouj and Weinstein (1997) who apply a characteristics-based representation to the product. As we mentioned earlier, in such a representation, the product is represented by four main vectors, and "Innovation can be defined accordingly as the changes affecting one or moreelements of one or more vectors of characteristics (both technical and service)or of competences" (Gallouj and Savona, 2009).

The importance of synthesis framework is also associated with the fact that the boundaries between goods and services have become more blurring. This framework is motivated by the convergence between service and manufacturing, where the distinction between innovation in services and manufacturing is becoming more difficult due to the service dynamic and innovation blurring. In this new context, two main changes are taking place: manufacturing becomes more like services and services become more like manufacturing. The former manufacturing firms produce more service products related to the main industrial products, and therefore higher portions of their turnovers are becoming achieved through selling services (Howells, 2000). This process is summed up as the 'Servicisation' of manufacturing industry (Quinn et al. 1990). In the latter, services firms become more innovative and higher parts of their innovative output are reflected by the traditional technological innovation in manufacturing, in other words, "services become more manufacturing-like in innovation" (Howells, 2000). Therefore, synthesis framework is required to "redefine the product in such a way that it offers a relatively solid framework to generalize a theory of innovation for material and immaterial product" (Gallouj and Savona, 2009). The synthesis approach "highlights the increasing complex and multidimensional character of modern services and manufacturing, including the increasing bundling of services and manufacturing into solutions'' (Salter and Tether, 2006).

The integrative approach is broadly used in the recent literature of innovation in services. In recent years, Most of the conceptual frameworks and empirical tests addressing innovation in services, apply an integrative approach in which both technological and non-technological innovation are emphasized (Hipp et al.2000; Tidd, Bessant and Pavitt, 2001 and Tidd, 2006).

The integrative approach is applied to complex or assembled services (e.g. transportation, tourism and health services). For example, Djellal and Gallouj (2005) developed a framework for analyzing innovation in hospital output that draws on integrative perspective for innovation in services, where not only technological-based innovations are considerably important but also non-technological innovation. Windrum and Garcia-Goni (2008) use a multi-agent integrative framework for studying innovation in health services, inspired by Gallouj and Weinstein (1997), and involving several variable aspects: including public service providers as well as the agent's competences and interest.

The integrative approach is the most efficient analytical framework in order to make a comparison in innovation distribution and performance between manufacturing and service sector. Both service and manufacturing are treated on an equal footing and integrated in one analytical framework (Tiri et al. 2006), which will be able to explain both material and immaterial innovation output or technological and non-technological output. The CIS4 survey that was designed to consider both technological (product and process innovation) and non-technological innovation (organizational and market innovation) in both service and manufacturing firms will provide us with the data needed to apply such framework.

3. Service innovation and economic performance

In a service economy, defining and identifying the whole range of innovation is not easy. It needs to go beyond the assimilation, technology-biased perspective. Anyhow, in services as in manufacturing innovation is a major source of economic performance. However, the link between innovation in services and economic variables such as productivity should be clarified. Indeed, in the service economy, the innovation gap is associated with a performance gap.

3.1. Innovations in services and productivity

Conceptually, there is no specific answer regarding the question of the degree and sign of the relationship between innovation in services and productivity. This is related to the service specificities which "influence the definition and measurement of productivity" (Djellal and Gallouj, 2008b).

The use of a technological or industrial approach for measuring innovation activities in services will lead to the under-estimation of both innovation and economic performance. It will lead to two gaps: an innovation gap and a performance gap (Djellal & Gallouj, 2010a). According to Djellal and Gallouj (2010b) "the innovation gap indicates that our economies contain invisible or hidden innovations that are not captured by the traditional indicators of innovation, while the performance gap is reflected in an underestimation of the efforts directed towards improving performance (or certain forms of performance) in those economies".

Measuring the productivity of immaterial and non technological-based services might need different methods from those employed to measure the productivity of material and technical activities in manufacturing sector.

Djellal and Gallouj (2008b) have developed a framework for analyzing the productivity strategies in services. This framework is similar to that used for addressing innovation as far as it distinguishes three different perspectives: assimilation, demarcation and synthesis.

First: in the assimilation perspective, the productivity strategy is similar to the industrialization strategy. The growth of productivity in this strategy depends on the elimination of intangible specificities in order to make services more material or tangible. In other words, they have to be made less ill-defined, less (or not at all) interactive and less immediate" (Djellal and Gallouj, 2008b). Elimination of service specificities includes different changes: replacement of services by manufactured goods, standardization of work procedures and production of high ICT-dependent services (electronic service).

Second: in the demarcation approach, the productivity concept is considered partially invalid because of the intangible, cognitive, and informational and relational nature of services. Therefore, the argument is that industrialization strategies are not always relevant and that strategies seeking to maintain service specificities are necessary. In such a perspective, Gadrey (1996) analyzes a professional rationalization strategy which consists of three main strategies: standardization, formalization of ad-hoc service activities (problem-solving approaches) and the use of organizational routines.

Third: in the integrative approach, the performance is the result of the synthesis of technological and service-based strategies. In other words, co-existence between assimilation and demarcation performance strategies is possible in the same services. This is frequent in complex services (e.g. health, tourism and transportation). For example, in health sector neither the industrialization strategies are consistent with informational trajectory (e.g. management of medical services and administration of information flow), nor relational trajectory (e.g. introduction of contractual service functions), nor the formalization strategies are consistent with material or technological trajectory (technical systems and equipment used in the processing of human activities).

3.2. Employment effect of innovation in services

Service sectors are the main source of employment in contemporary economies. They account for at least two-thirds of the jobs in all OECD countries. Thus, Innovation in services is likely to play an important role in such an employment dynamics. Therefore, it is important to analyze the nature of the relationship between service innovation and employment.

This debate was originated in manufacturing sector in order to analyze the effect of technological change on employment (Hicks, 1932; 1973; Ricardo, 1951; Say, 1964; Steuart, 1966; Mill, 1976; Pasinetti, 1981; Freeman et al., 1982; Hall and Heffernan, 1985; Freeman and Soete, 1987; Boyer, 1988; Appelbaum and Schettkat, 1995). In this context, two counter debates are posed. In the first, due to technological advancement, expected reduction in employment rate is likely to be experienced (Ricardo, 1951). The second debate is devoted to the compensation theory in which market compensation mechanisms are considered to be able to compensate the impact of process innovation on the reduction of employment rate (labour-saving) (Vivarelli, 1995, 2007; Vivarelli and Pianta, 2000 and Pianta, 2004). The compensation process of labour saving has several market mechanisms, for example, through new machines, decrease in prices, new investmentsand new products[2].

However, the compensation mechanism might face some obstacles in counterbalancing the labour saving effect of technology. For example, in the

[2] First, new jobs are created in the capital sector where new machines are produced (Say, 1964). Second, the process innovation lead to decreasing in costs of production and then to reduction in prices, thus the increasing of market demand (Steuart, 1966). Third, the increasing demand-due to decreasing in prices-leads to new profits. These profits are invested and lead to new jobs (Marshal, 1961 and Hicks, 1973). Finally, the technological innovation is not just employed by firms to decrease costs through process innovations, but it may lead to new radical product innovation, which consequently leads to creation of new jobs (Say, 1964).

application of the ICTs, the compensation mechanisms and the final employment impact of innovation face three main obstacles (Vivarelli, 2007): first, the difficultly to measure the diffusion of ICT; second, the dependence of the final employment effect of innovation on the institutional mechanism which may differ according to the economic level of discussion (micro, sectoral and macro level) or the country; finally, the interconnections between employment and other economic indicators (macroeconomic and cyclical conditions, the labour market dynamics and public policy). For example, some countries reformed the strict employment protection regulations to increase the capacity of the economy to increase employment.

In services, the technological trajectories are not the main form of innovation. Innovation activities include other non-technological elements. Therefore, the product/process dichotomy in employment analysis is not always consistent with service sector. The employment debate in manufacturing sector is probably insufficient to explain the employment effect of non-technological forms of innovation in services. For example, the new market strategies are important to change the consumer preferences and increase market-demands of new services, which affect the employment rate. In addition, some of the compensation mechanisms (like decrease in prices, new investments and new machines) in manufacturing industries cannot always be applied directly to services. For example, because of the immateriality and co-productivity of many service outputs, it is not always easy to fix their prices, and measure their intangible investment. In many services, there is an overlapping between types of innovation and it is not easy to disentangle them and distinguish labour-saving from labour-using effects.

Consequently, new methodological and conceptual frameworks might be needed which can explain the employment effect of immaterial and invisible activities beyond product/process dichotomy. New proxies are needed beyond that provided that they are developed on the basis of industrial sector like R&D and patents. In addition, new compensation and contradictory mechanisms need to be envisaged, which complicate the traditional idea in manufacturing sector that product innovation has labour-using effect and process innovation has labour-saving effect.

Due to the complexity and methodological obstacles, the empirical analyses of the impact of innovation on employment are rare in the service sector. Among the expansions are Evangelista and Savona (2003) and Peters (2004). Evangelista and Savona (2003) identify four factors determining the relationship between innovation and employment: technological opportunities, demand constraints, the specific innovation strategy and the organizational structure of the firm. They found a positive relationship between innovation in knowledge intensive business services and employment, and a negative relationship in the traditional (like trade and transport) and financial services. Peters (2004) used technological perspective i.e. product/process dichotomy to estimate the relationship between innovation in services and employment. He found that product innovations have a positive impact on the net employment for both manufacturing and service firms. In case of process innovation, he found a negative relationship for manufacturing firms with some differences between jobs, and insignificant reduction of employment for service firms.

Conclusion

In this chapter, we provided a survey for the literature of innovation in services using the assimilation-differentiation-integration framework. In addition to the discussion of service concept, we emphasized the importance of both demarcation and integrative approaches as important tools to focus on non-technological aspects of service innovation which were ignored due to the application of an assimilation view for innovation in service sectors. Also, the integrative approach is found to be the most promising and comprehensive theoretical perspective that is employed to discuss innovation in service sectors in most recent studies. The relationship between innovation in services and economic performance were discussed using productivity and employment as two important indicators for economic performance.

This discussion is important in the next chapter where a comparison between manufacturing and service sectors are implemented in relevant with the innovation behavior and the productivity effect of innovation, and where an integrative approach will be employed to show the innovation activities in both manufacturing and service sector.

Chapter 2: Innovation in French services compared to manufacturing: an empirical analysis based on CIS4

Introduction

In the last 20 years, innovation in services has shed an increasing discussion. This is linked to the increasing awareness of the role of services and service innovation as an engine of economic growth. As we have discussed it in previous chapter, new theories have been developed, seeking to take into account the peculiarities of innovation in services.

At the empirical level, the controversy between economists still remains strong about how service innovation should be defined, how productivity of innovative firms should be measured, and the nature of dissimilarities with industrial sector regarding innovation and performance. The difficulty to answer these questions refers to the unavailability of data and analytical tools, a great deal of methodological difficulties associated with service specificities, and also the bias towards manufacturing of existent indicators.

The peculiarities of service and service innovations might lead to major differences between service and manufacturing concerning the nature of innovation and innovation behavior and the relation with economic indicators (such as, productivity, employment and economic growth). For example, Internal R&D activities, acquisition of external R&D or the incorporation of new equipments that are used to reveal for innovation activities in manufacturing might not be consistent with invisible, non-technological and disembodied innovation activities in services (organizational changes, software, logistics, human resources, and cooperation with consumers). Similarly, the technological innovation output associated with product and process innovation is not the only innovation output in services, as far as non-technological innovation output is concerned, organizational and marketing innovation is likely to represent a significant share of innovation output. This probably also leads to differences between services and manufacturing firms regarding innovation impacts on economic performance.

In this chapter, we discuss the innovation behavior of French service firms in its various dimensions (innovation input, innovation output, impediments of innovation, etc) and the impact of innovation on economic performance, comparing them with manufacturing firms.

This discussion is based on data from CIS-4. The CIS-4 is a cross-sectional survey of all firms with over 10 employees in all 27 EU member states. In France, it also concerns firms with fewer than 10 employees (micro-firms). It covers a three-year period from the beginning of 2002 to the end of 2004, accounting 2004 as the reference year for the innovation variables. The survey is based on a sample of 17,000 firms which includes all manufacturing sectors and many, but not all, service sectors. Service activities which are the main concern of our research are grouped between 50 and 74 on the NACE codes ((NACE Rev. 1.1)[3] and they represent nearly 56.89% of all firms in The CIS4 data.

This article is organized as follows. In section 1, we review the empirical literature devoted to the comparison of innovation in service and manufacturing (regarding both innovation behaviors and innovation performance). In the section 2, we describe the empirical method (methodology used and data) that will investigate whether there are differences between innovation in services and innovation in manufacturing regarding

[3] Statistical classification of economic activities in the European Community

their behavior and its effect on economic performance. In section 3 we will present and discuss the main results.

1. Innovation in services compared to manufacturing: a survey of the literature

Comparative studies seek to establish a better understanding of the main differences and similarities between innovation in manufacturing and service sectors and of the key factors that drive the economic effect of innovation. They also seek to determine if innovation policies are biased towards any of the two sectors and the possibility of setting common policies to enhance innovation in both sectors.

The studies which include direct comparison between innovation in manufacturing and service firms are not very numerous. This is due, as mentioned in the previous chapter to methodological problems and data constraints associated with service specificities.

Recently, the production of data[4] about innovation activities in both manufacturing and service sectors enabled scholars to develop diverse empirical applications on innovation in services (Tether 2003; Miles 2005; Cainelli et al., 2006; Lööf and Heshmati, 2006), and to implement comparisons with innovation in manufacturing sector (Hughes and Wood (2000), Nijssen et al. 2006; Rubalcaba et al. (2010); Segarra-Blasco, 2010).

1.1. Innovation behavior comparison

Despite the increasing convergence between service and manufacturing sectors, it is expected to find a clear distinction or (considerable variation) in the innovation behavior between service and manufacturing. This distinction is related to the peculiarities of service and service innovation. For example, manufacturing firms depend highly on technological resources like R&D activities, acquisition of advance

[4] mainly through large scale surveys like harmonized CIS which is the most inclusive survey which provides technological and non-technological micro-data for innovation activities in service and manufacturing sectors in a large number of advanced economies

machinery and equipments in the innovation production, while service firms rely on knowledge, competences, training activities and skills to implement their innovation output. In addition, the innovation output of services might not be embodied in physical artifacts like in manufacturing.

A comprehensive understanding of the differences between the innovation behavior in service and manufacturing firms requires an investigation of various variables such as: innovation nature, process, protection, obstacles, etc.

In the literature, diverse types of indicators were employed to describe the innovation behavior either in manufacturing or service firms. Tiri et al. (2006) used input indicators, follow-up-investment indicators, output indicators, sources-of-information indicators, innovation-protection indicators, strategic and organizational indicators and other indicators as innovation-based indicators in his study of the differences in the innovation behavior of Flanders' (Belgium) service and manufacturing firms. They found important differences in innovation behavior between services and manufacturing sector and he concluded that services perform weakly compared to manufacturing firms. Evangelista (2006) used SIEPI database which is drawn from the CIS2 to compare manufacturing and service sector. He found that manufacturing industries are characterized by a higher technological intensity, more resources devoted to R&D, more use of patents and more interaction with S&T. Service sectors for their part have heterogeneous innovation behaviors, more organizational changes, investment in human resources and training activities, they interact more with suppliers of technology. In measuring intra-sector variance, he found that service firms have more variance than manufacturing industries.

On the basis of the CIS3 data across enterprise from the EU-27, Norway, Turkey and Iceland, Rubalcaba et al. (2010) found significant differences in innovation behavior between service and manufacturing sectors. The highest differences are found in innovation indicators related to the effects of innovation, organizational changes, protection methods and public funding. Services are found to be more innovative than manufacturing regarding product and organizational innovation (excluding management methods). Manufacturing firms apply more R&D activities as resources for innovation output. Regarding the effect of innovation, manufacturing firms have higher effect on factors related to costs, business and regulation adjustments, and environment.

Tether (2005) used "lnnobarometer 2002" survey data to make a comparison of the innovation patterns and approaches. He found that service firms implement more organizational changes, while manufacturing ones produce more technological innovation (product and process innovation). Regarding knowledge and technological sourcing, manufacturing firms' source is incarnated in an in-house R&D, acquisition of advanced machinery and equipment, and collaboration with universities and research institutes, while service firms source for collaboration with customers and suppliers, or acquisition of external intellectual property.

Finally, Hughes and Wood (2000) found that there is a greater variation in innovation activity (intensity and nature of innovation) within manufacturing and business services than between them and that the discussion about high difference between manufacturing and services has been exaggerated.

1.2. Innovation performance comparison

Major variations are also expected to be found regarding the economic effect of innovation (e.g. growth of employment and productivity). Service activities are the main economic activities in all the advanced economics. Therefore, their innovation activities are likely to have a crucial role in the enhancement of economic performance.

The different innovation types do not have the same influence in service as well as in manufacturing. As far as the technological innovations are the main innovation activities in manufacturing sector, their economic effects are more important compared to other innovation types. In the service sector, non-technological innovations are the main activities; therefore, their economic effect should be addressed carefully.

The testing of the relationship between innovation activities and economic performance has been highly focused on manufacturing sector (e.g. Crepon et al., 1998; Klomp and van Leeuwen, 1999; Evangelista, 1999; Cox and Frenz, 2002; Loof and Heshmati, 2001, 2002; Mairesse and Mohnen, 2002; Kremp and Mairesse, 2004). The estimations of the relationship between R&D expenditure, technological spillovers and productivity (Griliches, 1992; Ten Raa and Keller, 2000) are the main focus of these studies. In services, such empirical applications have been inexistent until recently, when the development of harmonized surveys like CIS stimulated them (Conceição et al., 2003; Lopes and Godinho, 2005; and Cainelli et al., 2006).

Prajogo (2006), using data from 194 service and manufacturing firms, compared the relationship between innovation performance (measured by product and process innovation) and business performance (measured by sales growth, market share and profitability) between manufacturing and service firms. He found no difference in terms of product and process innovation performance between service and manufacturing firms. In his analysis, the correlation between innovation and business performance is stronger in manufacturing than in service firms. He also found that firms in service sector are less likely to use intellectual property protection or use university as a source of information for innovation compared to firms in the manufacturing sector.

Segarra-Blasco (2010) found a considerable difference in performance between service and manufacturing firms and between low and high technological industries. R&D expenditures, output innovation, investment in physical capital, market share and export have positive effects on labour productivity in both the manufacturing and service sectors. Firm size, on the other hand, has a positive effect on productivity in manufacturing industries but not in services.

Loof and Heshmati (2002) found homogeneity between manufacturing and service sector regarding the relationship between innovation and economic performance in both firm level and growth rate dimensions.

Evangelista and Vezzani (2010) have developed a taxonomy for innovation depending on the innovation modes introduced by service and manufacturing firms and on the way technological (only product, only process, product and process, none) and non-technological (only organizational, only marketing, organizational and marketing, none) innovations are combined by firms. Four main clusters (innovation modes) have been identified: pure product, pure process, pure organizational and complex combination of product, process and organizational innovation. The four innovation modes where found to have a positive effect on economic performance but the complex mode was perceived as the most effective one. Sectoral differences between manufacturing and service sector were clear in the relevance of the effect of innovation modes on the economic performance (turnover growth rate). Product and process innovation were only significant for manufacturing sector, organizational innovation in (paradoxically) was more significant for manufacturing sector than service sector, while the adoption of complex innovation was more efficient for service than manufacturing firms.
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2. Data and methodology

We will use a "manufacturing-services comparative framework" (Evangelista and Vezzani, 2010), to explore the differences between manufacturing and service sectors regarding the innovation behavior and the economic effect of innovation. Due to the structure of the CIS4 questionnaire, we are constrained by the available data about the innovation behavior and the economic performance. The same descriptive evidence, econometric framework and an identical model specification are used to describe the innovation behavior and estimate the economic performance-innovation relationship for both manufacturing and service firms.

2.1. Measuring the innovation behavior

To reveal the possible differences and similarities in innovation behavior between French manufacturing and service firms, analyses of variance (ANOVAs) will be employed that provide a statistical test of specific innovation-related variables. We will assume a fixed-effect model that such data comes from normal populations might only differ in their means. We use the logarithm of variables which don't meet the normality and homogeneity of variance (Rubalcaba et al.2010). We will also study the intra-sectoral heterogeneity regarding the good-service comparison, which shows if differences between service and manufacturing sector are greater than that among the service sub-sectors (Rubalcaba et al. 2010). It is possible to find no difference between service and manufacturing sector regarding certain innovation indicators, but heterogeneity between service sub-sectors. To test the degree of intra-sectoral heterogeneity compared with inter-sectoral differences, a simple distinctiveness coefficient will be used (Rubalcaba et al. 2010).

The service sector is highly heterogeneous. Therefore, it is expected that there is more heterogeneity in innovation behavior for service than manufacturing firms. The coefficient of variation indexes (the ratio between standard deviation and the mean of each indicator) will be computed to reveal the variation of each innovation-related indicator within services and manufacturing firms.

The comparison test will include a wide range of indicators associated with innovation (innovation-related variables) (see table 1): input indicators, technological innovation output indicators, non-technological innovation output indicators, sources of information indicators, innovation-protection indicators, innovation expenditure, innovation effect, obstacles of innovation indicators and public support for innovation indicators. Due to the specificities of the innovation in the service sector which we have reviewed, it is expected to find significant differences between service and manufacturing innovation behaviors for many of these indicators.

Our analysis is limited to manufacturing and service firms which implement innovation activities. In the CIS4, the firm is considered innovative if one of these criteria is met: (1) the firm has introduced product innovation (new or significantly improved goods and services); (2) process innovation (new or significantly production process, distribution method, or support activity for your goods and services; (3) organizational innovation (new or significant changes in firm structures or management methods); market innovation (new or significantly improved designs or sales methods).

2.2. The relationships between innovation and economic performance

The definition of the suitable metrics for both economic performance and innovation is vital to assess the relationship between innovation activity and economic performance. In the measuring of economic performance of innovative manufacturing firms, total factor productivity (TFP) is one of the most used techniques (Zheng et al., 2003; Griliches, 1992; Castellacci and Zheng, 2008). Other measures are also employed, for example, per capita GDP (Fagerberg and Verspagen, 1996, Cappelen et al., 1999), share of innovation sales (Sirilli and Evangelista, 1998; Crepon et al. 1998; Mohnen et al, 2006; Blochand Graversen, 2008) and labour productivity (sales/number of employee) (Cainelli et al. 2006). Some of these productivity metrics like turnover from introducing new product innovation, labour productivity or capital-labour multifactor productivity are not always robust for measuring service performance, because of the obstacles to use such metrics in measuring invisible and fuzzy output. This might lead to under-estimation of the real economic output of services and of productivity. Therefore, to overcome such metrics' deficiencies, new metrics should be used such as satisfaction, quality adjustment, added value and growth rate of turnover. For example, Fixler and Zieschang (1999) use quality adjustment to capture the effect of new innovation in financial service industry in the USA.

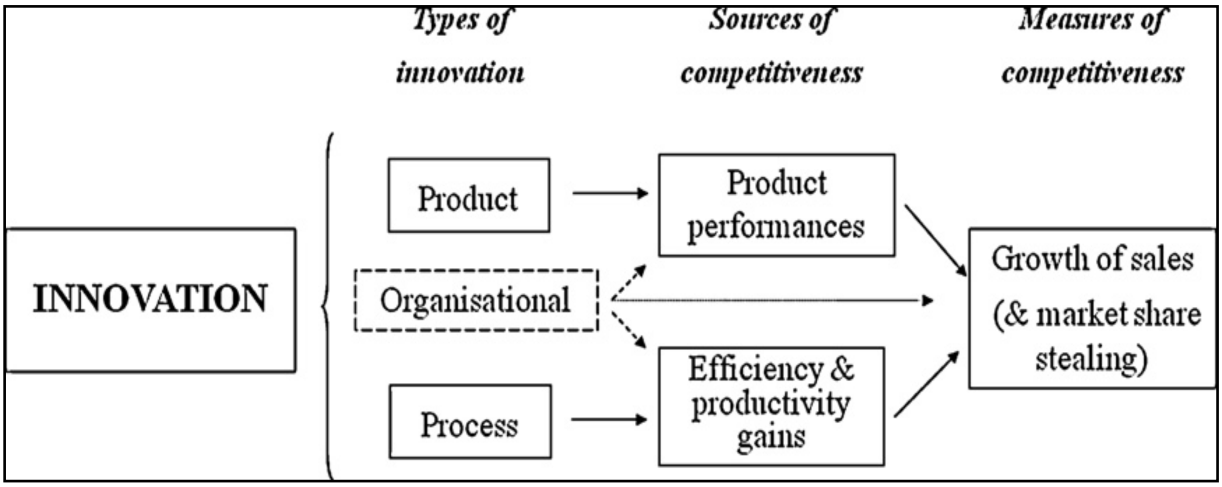
Evangelista and Vezzani (2010), use “growth of turnover” as a comprehensive indicator to measure the economic performance of innovation in both service and manufacturing service firms, in order to overcome any under-estimation of economic effect of innovation in services due to service peculiarities. This indicator is “rather consistent with a Schumpeterian-evolutionary perspective of the innovation-performance relationship “ (Evangelista and Vezzani, 2010). Growth of turnover measured by the difference between “turnover/number of employees” between 2004 and 2002 will be employed here to measure the economic performance of French service firms between the years 2002 and 2004.

The use of technological indicators like R&D, patents, publications and machines are frequent in the measuring of innovation output in the manufacturing sector. But, these metrics are likely not to be consistent with service innovations and may lead to underestimation of the economic performance. The using of non-technical based indicators like organizational changes, new marketing methods, social changes etc are likely to be more efficient in measuring innovation activities in services.

Here, we use innovation output metrics to characterize the innovation activities. Four innovation modes are included, two are technological innovation activities (technoinnov_only), which include both product and process innovation, while the others are non-technological (no_technoinnov_only) and include (organizational and market innovation). Some problems may arise in measuring separately the effect of product, process and organizational innovation on economic performance in service sector. One is associated with the difficulties of separation between product and process innovation because of co-terminality of the production and consumption. This deficiency is likely to be solved by using synthesis perspective for innovation in services (Evangelista, 2006, Evangelista and Vezzani, 2010). Another deficiency is linked to the high heterogeneity and multiform dimensions of firms’ organizational competences and assets. In this context, organizational competences and strategies have indirect effect on economic performance through their influences on the product and process innovation (see figure 1). In other words, firms' organizational competences (new business structures, management and administrative techniques and new strategies) could be vital for stimulating process and product innovation. This might lead to some statistical problems when measuring separately the effect of product, process and organizational innovation on economic performance and determine the real effect of each innovation mode.

Thus, technological and non-technological innovation will be added as complements rather than substitutes to each other(Hollenstein, 2003; Tether and Tajar, 2008), where the co-existence between the technological and non-technological innovation could lead to more efficient output in measuring the impact of innovation output on economic performance. Therefore, a new variable will be included that measures the interaction (co-existence) between technological and non-technological innovation (tech&non-tech_innov).

Figure 1: A stylized representation of the innovation-performance linkages.



Source: Evangelista and Vezzani (2010)

We control for 1) firm size to show the relationship between economic performance and size of firms. 2) Lnprod02_04 stands for the change in labour productivity measured by the logarithm of difference between turnover/employee (2004) and turnover/employee (2002). 3) Two variables for the demand-pull mechanism: Hdem which measures the importance of uncertain demand for innovative output as an impediment to innovation, and Hmar that measures the absent of demand for innovation output. 4) Subsectors and regions to verify whether there are differences between different subsectors and regions regarding the impact on economic performance. Regions are divided into 26 main regions; four were dropped (Gaudeloupe, Guyane, Martinique and Reunion) from the analysis due to some statistical problems. Subsector either in manufacturing or services are divided according to Oslo Manual (2005).

2.3. The data

We will use the micro-level data made available by the fourth version of the community innovation survey (CIS4) to make comparison between service and manufacturing sector regarding the innovation behavior and the link between innovation activities and economic performance. The CIS4 highlights a set of innovation indicators which cover specific facets of innovation activities and performance for manufacturing and most of service firms between years 2002 and 2004. Firms are asked about their innovation activities, the source of knowledge and information, expenditures and human resources dedicated to such activities, the objectives of innovation and obstacles for innovation processes.

To study the economic effect of innovation activities, the CIS4 provides some indicators like value added, labour productivity, turnover and growth of sales. Some of these indicators (e.g. labour productivity, turnover) are not efficient in measuring the right effect of service innovation because of the difficulties in measuring the actual value of innovation output due to the specificities of services (e.g. co-terminality and immateriality). Compared with previous versions of The CIS (CIS1, CIS2 and CIS3), CIS4 is also focused on non-technological innovation activities. It includes questions about the tacit sources of innovation activities (like, training and know-how activities) and organizational and marketing innovation activities as new modes of innovation output. This is important to verify whether technological and non-technological strategies lead to different economic outcomes for service and manufacturing sectors, to reduce the innovation gap between service and manufacturing.

3. Results

This section provides an overview of the main characteristics of innovation in the French manufacturing and service sector. It shows the differences in innovation behavior between goods and services according to a large set of indicators. It also focuses on the differences between goods and services regarding the effect of both technological and non-technological innovation on economic performance.

3.1. Innovation behavior

Table1 reports the result of the statistical test of the difference in innovation behavior between service firms and manufacturing firms, for a wide set of innovation indicator. Service and manufacturing sectors show more differences than similarities regarding most of the innovation behavior indicators. This is consistent with previous literatures that also emphasized such differences (e.g. Tether, 2005; Evangelista, 2006; Rubalcaba et al.2010).

a. Innovation input

According to innovation input, the propensity for manufacturing firms to apply both intramural (88.2% vs. 72.4%) and extramural R&D (46.2% vs. 33.3%) is higher than that for service firms. Service firms have more propensity to implement training activities (73.5% vs. 62.1%), and acquiring external knowledge other than R&D (32.5% vs. 26.2%) than manufacturing firms. This result is consistent with the technological nature and high R&D intensity of innovation activities in manufacturing sector. It is also consistent with the high dependency of service innovation on external knowledge either from manufacturing sector or from cooperation with actors (competitive firms, consumers and suppliers) beyond the boundaries of the firm. Also, it confirms the high dependence on human resources (such as higher skills and knowledge) who need new training activities to produce innovation.

Technological innovations either produced internally (intramural R&D) or adopted from manufacturing sector (Extramural R&D) are also important sources for innovation activities in service sector. This explains the high dependence of some service sectors (mainly knowledge intensive business services) on the ICTs.

A similar result is obtained regarding the employment of R&D activities. Manufacturing firms invest more than service firms in both internal (4671M$ vs. 3937.9M$) and external R&D (1780.5M$ vs. 402.3M$). Service firms have more expenditure than manufacturing firms for both anacquisition of machinery, equipment and software expenditures and acquisition of other external knowledge. This also confirms the dependence of service firms' on external knowledge and complex technologies (like machines and equipments).

a. Innovation output

The two sectors have different innovation modes. Manufacturing sector is more directed towards technological innovation output through its trend to introduce more product (41.8% versus 20.8%) and process innovation (44.8% versus 29.6%). Moreover, manufacturing firms have a higher propensity to introduce organizational innovation (47% versus 39.7%), while the service sector introduces more market innovation than manufacturing firms (29.9% versus 25.4%). As for technological product and process innovation, the result is consistent with the innovation literature where manufacturing firms are considered more likely to introduce material and technical-based products. But, the unexpected result is for organizational innovation which is the main innovation activity for both manufacturing and service firms.

The important share of manufacturing firms introducing organizational innovation denotes a high score of complementarity between technological innovation (product and process) and organizational innovation (see section 3.2 which confirms this complementarity). This also provides another evidence for the convergence between manufacturing and service sectors, and the trend of manufacturing firms to provide product related services (i.e. Servicisation) we have mentioned in chapter 1.

In services, the fact that organizational innovation is the main innovation activity is consistent with the literature in the last 20 years which confirms the high intensity of non-technological innovation activities in service sectors (see Gallouj, 1994, 2002; Gallouj & Gallouj, 1996 and Sundbo, 1997), and the high importance of organizational changes as competitive elements in services (Evangelista & Sirilli, 1998).

Table 1: Significant Differences between Goods and Services Innovation: Selected Innovation-related Variables

Grouping of Innovation variables	**Selected Variables**	**Average services (%)**	**Average Goods (%)**	**P**		**F**	**R²**
Innovation Input	Intramural (in-house or intramural) R&D	72.4	88.2	<0.001	***	37.7	0.089
	Extramural R&D activities	33.3	46.2	0.0001	***	15.3	0.038
	Acquisition of machinery, equipment and software	67.05	66.2	0.768		0.09	0.00022
	Acquisition of other external knowledge	32.5	26.2	0.0156	***	5.91	0.0152
	Training	73.5	62.1	0.0001	***	15.4	0.038
	Market introduction of innovations	53.1	47.1	0.053		3.75	0.0097
	Other preparations	33.6	43.8	<0.0005	***	12.35	0.031
Innovation activity expenditures	Internal R&D expenditures	3937.9	4671.4	0.023	***	5.17	0.001
	External R&D expenditures	402.3	1780.5	<0.001	***	34.3	0.007
	Acquisition of machinery, equipment and software expenditures	416.6	371.05	0.0099	***	6.66	0.0013
	Acquisition of other external knowledge	187.49	45.7	<0.0001	***	177.8	0.035
Innovation output							
Technological innovation	Product innovation	20.8	41.8	<0.0001	***	73.9	0.14
	Process innovation	29.6	44.8	<0.0001	***	46.6	0.097
Non-technological innovation	Organizational innovation	39.7	47	0.0019	***	9.72	0.022
	Market innovation	29.9	25.4	<0.028	***	4.8	0.011
Innovation-protection (intellectual property rights)	Apply for a patent	9.9	30.8	<0.0001	***	82.5	0.16
	Register an industrial design	10.3	21.9	<0.0001	***	41.6	0.087
	Register a trademark	30.2	34.16	0.109		2.58	0.0059
	Claim copyright	8.2	7.2	0.45		0.57	0.001
	Secret	10.2	25.4	<0.0001	***	60.6	0.123
	Complexityto thedesign	9.3	20.1	<0.001	***	39.8	0.084
	Technological advance of competitors	12.8	27.4	<0.001	***	55.01	0.113
Public support for innovation	Local or regional authorities	8.2	8.9	0.705		0.14	0.0003
	Central government(including central government agencies or ministries)	11.03	22.8	<0.0001	***	24.6	0.060
	The European Union(EU)	4.9	6.5	0.219		1.5	0.003
	Tax credits (including research tax credit)	8.6	29.5	<0.0001	***	72.2	0.158
Innovation effect							

Product oriented effect	Increased range of goods and services	78.4	87.5	0.0003	***	13.52	0.035
	Entered new markets or increased market share	83.7	88.8	0.014	***	6.04	0.016
	Improved quality of goods or services	87.2	84.8	0.28		1.16	0.003
Process oriented effect	Improved flexibility of production or service provision	65.1	61.3	0.189		1.73	0.004
	Increased capacity of production or service provision	63.4	63.1	0.91		0.01	0.00003
	Reduced labour cost per unit output	62.8	71.8	0.0015	***	10.17	0.026
	Reduced material and energy per uni output	38.5	50.5	<0.0001	***	16.1	0.041
	Reduced environmental impacts or improved health and safety	42.9	60.3	<0.0001	***	29.4	0.073
	Met regulatory requirements	57.2	64.9	0.014	***	6.08	0.016
Effect of organizational innovation	Reduced time to respond to customer or supplier needs	71.7	70.7	0.67		0.18	0.0004
	Improved quality of your goods or services	85.4	82.7	0.17		1.87	0.004
	Reduced costs per unit output	56.2	67.4	<0.0001	***	19.8	0.047
	Improved employee satisfaction and/or reduced rates of employee turnover	58.6	52.4	0.016		5.86	0.014
Impediments of innovation							
Cost factors	Lack of funds within your enterprise or group	42.2	51.8	<0.0001	***	18.5	0.04
	Lack of finance form sources outside your enterprise	19.3	23.7	0.026	***	4.97	0.011
	Innovation costs too high	36.2	50.5	<0.0001	***	43.57	0.09
Knowledge factors	Lack of qualified personnel	27.4	37.7	<0.0001	***	27.9	0.06
	Lack of information on technology	16.4	23.8	<0.0001	***	17.79	0.039
	Lack of information on markets	16.1	24.6	<0.0001	***	23.25	0.051
	Difficulty in finding cooperation partners for innovation	17.8	27.5	<0.0001	***	27.46	0.059
Market factors	Market dominated by established enterprises	26.7	36.8	<0.0001	***	26.38	0.057
	Uncertain demand for innovative goods or services	30.3	44.7	<0.0001	***	44.56	0.09
Reason not to innovate	No need due to prior innovations	19.1	18.6	0.816		0.05	0.0001
	No need because of no demand for innovations	38.1	30.1	0.0007	***	11.76	0.026
Source of information							
Internal	Other enterprise within your enterprise group	86.6	89.3	0.223		1.49	0.004
Market source	Supplier of equipment, materials, components, or software	55.4	54.2	0.674		0.18	0.0004
	Clients or customers	60.3	60.9	0.839		0.04	0.0001
	Competitors or other enterprise in your sector	40.2	41.3	0.73		0.12	0.0003
	Consultants, commercial labs, or private R&D institutes	26.1	24.4	0.52		0.41	0.001
Institutional sources	Universities or other higher education institutions	7.7	21.7	<0.0001	***	34.9	0.083
	Public R&D organization or private not-for- profit research institutes	7.99	11.9	0.047	***	3.97	0.01
	Conferences, trade fairs, exhibitions	29.6	36.1	0.022	***	5.27	0.014
Other sources	Scientific journals and trade/technical publications	30	33.2	0.23		1.42	0.003
	Professional and industry associations	23.6	24.2	0.82		0.05	0.0001

b. Source of information

Except for institutional sources (universities or higher education institutions, governments or public research centers, conferences, trade fairs and exhibitions), it is clear from table 1 that there is no significant difference between service and manufacturing firms in regard to sources of information. The dependence on public sources of information like universities, public R&D organization or private not-for-profit research institutes is lower in services than in manufacturing sectors. This is explained by the high technological nature of innovation outputs in manufacturing sectors. Thus, they are expected to depend highly on knowledge and the R&D activities from universities and public research centers.

Making a comparison between the different sources of information, it seems that for both manufacturing and service sectors, the public and institutional sources are the least appreciated sources compared with the high dependence on internal sources (other enterprises in the same group) or customers.

c. Innovation protection

The intellectual property rights (IPR) aim to capture the benefits of innovation processes and sustain competitive advantage either in manufacturing or service firms. Table 1 shows that manufacturing firms use more protection for innovation (intellectual property rights) than service firms. This is evidenced for most of the protection systems considered: patents (30.8% versus 9.9%), industrial designs (21.9% vs. 10.3%), secrets (25.4% vs. 10.2%), complexity to the designs (20.1% vs. 9.3%) and technological advance of competitors (27.4% vs. 12.8%).

These results are not unexpected. They are consistent with the general fact that the IPR policies are more efficient (suitable) in manufacturing sector, and that services are more likely to use an informal IP. In services, innovation outputs are easily copied; therefore the IP policies like patents and industrial designs are weak to protect. In some cases, the lower rate of trademarks in services is due to the lack of service firms for information and experience in using intellectual property (Arundel et al. 2007). Service firms seek for informal methods of protection such as complexity, lead times and "controlling access to complementary assets, such as distribution channels, marketing and branding" (Salter et Tether. 2006).

d. Public support for innovation

Table 1 also shows that service firms receive less assistance from public bodies than manufacturing firms. This is confirmed in the case of public support by central government (22.8% versus 11.03%) and in the case of tax credits (29.5% versus 8.6%). In the case of support from regional authorities and European Union, there are no significant differences between manufacturing and service firms. The results are consistent with the fact that the public supports for innovation favor industrial sector over service sector (Arundel et al. 2007).

e. Impediments of innovation

Manufacturing firms appear to be more affected by obstacles to innovation than service firms, for most of the factors considered (cost factors, knowledge factors, and market factors), except the absence of demand for innovation. In other words, the proportion of manufacturing firms that assess that obstacles of innovation factors have medium or high impeding effects on their innovation is higher than service. Lack of fund within the enterprise or enterprise group, innovation costs and uncertain demands for innovation outputs are the main barriers that hinder innovation both in services and in manufacturing firms. This result here may explain the result in the previous point (public support for innovation) which shows that manufacturing firms obtain more supports for innovation than service firms.

f. Effect of innovation

According to the effect of innovation, table 1 shows that most of product oriented effect factors (increased range of goods and the entered of new markets or increased market share) and process oriented effect factors (reduced labour cost per unit output, reduced material and energy per unit output, reduced environmental impacts or improved health and safety and met regulatory requirements) are more significant for manufacturing than service sectors. This is expected because of the technological characteristic of innovation in manufacturing where product and process innovation are considered to be the two main technological innovation outputs.

The effect of organizational innovation is very similar for both manufacturing and service sectors. Except for reduced costs per unit output which is more significant for manufacturing firms, we find no significant difference between manufacturing and service firms for the other variables (reduced time to respond to customer or supplier needs, improved quality of your goods or services, improved employee satisfaction and/or reduced rates of employee turnover). This explains the high production of organizational innovation in both manufacturing and service firms (see table 1).

3.2. Innovation and firm's economic performance

The results of the estimation carried out for the service sector (see table 2) show that technoinnov_only has no significant effect on firms' economic performance (growth of turnover),while no_technoinnov_only has positive significant effect on firms' performance. This result is consistent with the higher propensity for service firms to implement non-technological innovation compared with technological ones (see table 1). It confirms the importance of non-technological innovation as an engine of theeconomic growth in service sectors.

Table 2: The impact of innovation on service firms performance GLM estimates

Parameter	**Estimate**	**Pr > |t|**
Intercept	0.231	<.0001
Size (ref = size3)		
size1 1	-.044***	<.0001
size1 2	-.031***	<.0001
lnprod02	-.025***	<.0001
Hdem	-.005	0.313
Hmar	0.004	0.380
innovation output		
Technoinnov_only	0.016	0.106
no_technoinnov_only	0.019***	0.002
tech&non-tech_innov	0.039***	<.0001
Region(ref=RhoneAlpes)		
Alsace	-.007	0.661
Aquitaine	0.001	0.924
Auvergne	-.009	0.639
BasseNormandie	-.034*	0.071
Bourgogne	-.025	0.155
Bretagne	-.006	0.626
Centre	-.019	0.197
Champagne	-.006	0.737
Corse	0.003	0.927
FrancheComte	-.010	0.642
Guadeloupe	0.027	0.322
HauteNormandie	-.026	0.100
IDF	-.047***	<.0001
Languedoc	-.002	0.884
Limousin	0.006	0.807
Lorraine	0.007	0.619
MidiPyrenees	0.014	0.315
Nord	-.028**	0.028
PaysLoire	-.007	0.546
Picardie	-.008	0.650
PoitouCharentes	-.005	0.777
Provence	0.007	0.512
Subsector(ref=water transport)		
Other community, soc	0.047	0.229
R&D	-.007	0.847
air transport	0.074	0.250
computer and related	-.001	0.976
Financial intermédiation	0.255***	<.0001
hotels & retaurants	-.034	0.351
Land transport	0.037	0.296
other business activ	0.021	0.550
other retail trade	0.024	0.502
other wholesale trad.	0.028	0.420
post and telecommuni	0.042	0.308
realstate and rentin	0.044	0.228
sale, retail, mainte	0.021	0.557
supporting and auxil	0.012	0.750
R-suared	0.085	

* Significant at the 0.10 level.
** Significant at the 0.05 level.
*** Significant at the 0.01 level

Table 2 shows also that the complementarity between technological and non-technological innovation (tech&non-tech_innov) has the highest effect on firms' performance, which confirm the strong complementarities between different types of innovation in service sectors (Milgrom and Roberts 1995; Laursen and Mahnke 2001; Laursen and Foss 2003). The co-existence between technological and non-technological innovation leads to higher firm performance. In other words, technological innovations iare more efficient when they are supported by non-technological innovations like new organizational approaches, operational functioning, work organizations, standardized methods of management control, marketing designs and procedures, etc. The tech&non-tech_innov variable gives the real effect of non-technological innovation on economic performance by capturing also the indirect effect on economic performance that organizational competences and strategies may have through their influences on the product and process innovation. This discussion is consistent with Salter et al (2006) who said that "this not to say that 'physical' technologies are unimportant, only that they need to be seen in conjunction with skills (including nontechnical skills) and organizational practices and changes to these – in short there are complementarities between innovations in 'physical technologies' and innovations in social technologies".

With regard to the estimation of the relationship between innovation output and firms' performance in manufacturing firms, we observe that there is a positive relationship between both technoinnov_only and no_technoinnov_only and growth of turnover (see table 3). However technoinnov_only has stronger impact on economic performance than no_technoinnov_only. This is consistent with the fact that technological innovations are considered the main innovation activities in manufacturing sector.

Table 3: The impact of innovation on manufacturing firms' performance GLM estimates.

Parameter	Estimate	Pr > |t|
Intercept	0.166	<.0001
Size (ref=size3)		
size1 1	-.005	0.495
size1 2	0.004	0.62
Lnprod02	-.027***	<.0001
Hdem	-.021***	0.0005
Hmar	0.006	0.301
Innovation output		
technoinnov_only	0.029***	0.0009
no_technoinnov_only	0.018**	0.041
tech&non-tech_innov	0.048***	<.0001
Region(ref=RhoneAlpes)		
Alsace	0.005	0.737
Aquitaine	0.007	0.625
Auvergne	0.009	0.624
BasseNormandie	0.027	0.173
Bourgogne	0.004	0.819
Bretagne	0.017	0.239
Centre	0.017	0.251
Champagne	0.014	0.453
Corse	0.025	0.712
FrancheComte	0.003	0.880
Guadeloupe	0.102	0.109
HauteNormandie	0.007	0.736
IDF	-.009	0.321
Languedoc	0.016	0.443
Limousin	-.018	0.494
Lorraine	0.006	0.720
MidiPyrenees	0.016	0.306
Nord	0.003	0.775
PaysLoire	0.043***	0.0006
Picardie	-.005	0.749
PoitouCharentes	0.010	0.543
Provence	0.010	0.502
Subsector(ref=Wood and Cork)		
Basic metals	0.011	0.675
Chemical products less pharmaceuticals	0.011	0.585
Chemicals and chemical products	0.013	0.485
Coke, refined petroleum products and nuclear fuel	0.054	0.144
Electrical machinery	0.007	0.711
Electricity, gas and water supply	0.039	0.119
Electronic equipment	-.038*	0.098
Fabricated metal products (except machinery and equipment)	0.013	0.454
Food products and beverages	0.010	0.547
Furniture, other manufacturing n.e.c.	-.029	0.150
Leather products and footwear	-.069***	0.010
Minning and quarrying	0.054**	0.028
Machinery n.e.c.	-.002	0.935
Medical, precision and optical instruments, watches, clocks	0.022	0.287
Motor vehicles	0.008	0.675
Non-metallic mineral products	0.034	0.096
Office, accounting and computing machinery	-.012	0.801
Other transport equipment	-.026	0.251
Publishing, printing and reproduction of recorded media	-.0125	0.530
Pulp, paper and paper products	-.064***	0.006
Recycling	0.240***	<.0001
Textiles	-.098***	<.0001
Tobacco products	0.322**	0.016
Wearing apparel and fur	-.063***	0.003
R-squared	0.045	

* Significant at the 0.10 level.
** Significant at the 0.05 level.
*** Significant at the 0.01 level

For manufacturing firms tech&non-tech_innov (i.e. the contribution of technological and non-technological innovation) also has the strongest effect on economic growth amongst the three innovation strategies. Thus, also in manufacturing, the technological innovation activities achieve their maximum effect when supported by the non-technological innovation activities.

In the comparison between service and manufacturing sector regarding the estimation of the relationship between innovation and firm's performance, results show that both no_technoinnov_only and tech&non-tech_inno variables are the main drivers for firms' economic performance. The impact of no_technoinnov_only is slightly bigger in the case of service firms which is consistent with the important role of non-technological innovation activities in service sectors.

Tech&non-tech_innov strategy is the most efficient innovation strategy. It is more rewarding than no_technoinnov_only and technoinnov-only in both service and manufacturing sectors. However it is more efficient in manufacturing than in service sectors. In other words, the economic value of innovation complementarity is greater in manufacturing. This result confirms Evangelista and Vezzani's result (2010) and in line with the systemic approach to innovation, i.e. the combination of technological and non-technological modes of innovation gives firms a true competitive advantage either in manufacturing or service sector. But, it contrasts with Hipp et al.'s argument (2000) according to which the relationship between various forms of innovations (technological and non-technological) in service has more economic value than in manufacturing sectors. This may be consistent with the high employment of product, process and organizational innovation activities in manufacturing sectors (see table 4).

Table 4: share of service and manufacturing firms introducing different types of innovations

Innovation activity	Percentage	
	Service firms	Manufacturing firms
Firms implement one or more innovation mode	54	63
Product innovation	20	35
Process innovation	29	38
Organizational innovation	40	43
Market innovation	27	22

The estimation of the control variables shows low heterogeneity between service subsectors in regards with their effect on economic performance (see table 2). Except for financial intermediation -which have more positive effect on economic performance than water transport- there are no significant differences between other service subsectors in their influence on economic performance. The regional variable shows unexpected results: there is no difference in economic performance between most of the regions. Also, IDF region has lower effect on economic performance than most of the other regions (see table 2). This results contrast with the fact that IDF is the most important region in France in regards with population, wealth, GDP and employment.

Manufacturing subsectors show more heterogeneity (sectoral variations) than service subsectors in regards with the economic performance. Tobacco products, recycling, mining and quarrying subsectors have the highest economic performance (more associated with economic performance) while electronic equipment, leather products and footwear, pulp, paper and paper products, textiles, wearing apparel and fur have the least economic performance. The regional variable shows no significant differences in economic performance for most of the French regions, i.e. there is low variation on the regional level regarding the effect on economic performance. Except Pays de la Loire -which have the highest economic performance- all the French regions have the same economic performance. This result is strange, knowing the heterogeneity between French regions in size, GDP and economic activities.

In regards with the economic performance of service firms, we find that the inter-sectoral differences are larger than intra-sectoral differences. No_technoinnov_only,technoinnov-only and tech&non-tech_innov have heterogeneous effects on the economic performance between manufacturing and service firms while no significant differences between service subsectors are found in regards with the economic performance.

Large service firms are more efficient in enhancing firms' economic performance, which is consistent with the well-known fact that large firms have more economic performance than small firms. There is no difference regarding firm size in case of manufacturing firms, i.e. small, medium and large size manufacturing firms have similar economic performance. This result contradicts the fact that in many countries large industrial firms perform more than small ones. Firms' productivity in 2002 (lnprod02) has a significant negative effect on firms' economic performance for both manufacturing and service firms. This shows the presence of catching-up processes in the less efficient firms (which are far from the technological frontier). Uncertain demand (hdem) and the absence of demand (hmar) for innovation output have no significant effect in the case of service firms, while they have a negative effect on economic performance for manufacturing firms. This result confirms the presence of demand-pull effect on manufacturing firms' performance but not for service firms.

Conclusion

In this work, we present an exploratory exercise for the innovation behavior in both manufacturing and service firms, and also we provide an empirical evidence for the relationship between innovation and economic performance. The results show that the innovation behaviors in service are significantly different than those in manufacturing sectors for many variables, but the intensity of the effect was not high for most of these variables. A significant positive relationship between innovation and economic growth is found in both manufacturing and service firms. In services, non-technological innovation has more significant effect than technological innovation, while technological innovation has more significant effect than non-technological innovation in manufacturing sectors. Also, the mix strategy of technological and non-technological innovation is the most efficient innovation strategy for economic growth in both manufacturing and service firms.

Conclusion of part 1

In this part, we introduced a review of the innovation in services associated with a comparison study between services and manufacturing with regard to innovation behavior and economic performance of innovative firms. The assimilation-demarcation and integrative framework is one of the most important debates for innovation in service sectors. Most of recent studies use the integrative approach as a comprehensive perspective for studying innovation either at theoretical or empirical level. In the empirical analysis, we found that the service sectors perform differently from manufacturing sectors either in their innovation behaviors or economic effect.

One of the most important results in this part is related to the positive relationship between innovation in services and economic performance. This leads to a search for new strategies which can improve the behavior and economic effect of innovation in services, like for example using the cooperation for innovation or innovation networks which are employed successfully in manufacturing sector.

Part 2: From TechPPINs to ServPPINs: A conceptual framework

Introduction

In the second part, we discuss the shift from TechPPINs to ServPPINs i.e. the way the IN concept has to be changed to better take into account services and innovation in services. This part will focus on the synergies that public and private actors can mobilize through collaboration to produce innovation. We will also show why the TechPPINs conceptual framework associated with the manufacturing sector might not be efficient to explain the innovation processes in service sectors. Consequently, one objective is to construct a theoretical perspective (conceptual framework) which can explain the innovation processes in service sector where different modes of innovation are produced in cooperation between public and private service organizations.

This part is composed of two chapters:
Chapter 3 provides a definition of TechPPINs. It first shows the difference between the PPPs devoted to the production of products and the PPPs in which the diffusion and production of cognitive resources (skills, knowledge, technologies, etc) is the core objective of the cooperation.

Secondly, constructing efficient interaction processes between heterogeneous actors to produce a successful innovation output is one of the most intriguing questions in the new complex and open model of innovation. In this chapter and the next one, we shed some light on this question formalizing a conceptual framework that contains the constituent elements that form the mechanism of innovation in such PPINs. The conceptual framework can be described by the following elements: 1) Heterogeneous actors i.e. the inclusion of public and private actors as main factors in the IN. 2) The process of interactions between different actors is a dynamic and evolutionary process. 3) The processes of ties decoupling and fragmentation are combined with the emergent and development of social network. 4) The innovation network has an evolutionary path (life cycle).

A different conceptual framework is developed in chapter 4 to offset the deficiencies of traditional INs to account for innovation in services. The conceptual framework in ServPPINs is also described as a comprehensive mechanism that illustrates the process of innovations in complex, interactive, social and dynamic network structure. Thus, the development of innovation in services is an evolutionary and interactive process that entails intensive collaborations and social interactions between heterogeneous public (e.g. universities, public research centers, public services like health and transport and public institutions) and private service actors (e.g. financial services, consultants, hotels and restaurants, and trade). The communications and interactions between network actors assure the production and diffusion of both visible/invisible and technological/non-technological resources employed to develop new innovations.

The construction of the framework here is different from that for TechPPINs. Conceptual framework with several innovation mechanisms is essential here to be consistent with the service innovation objective of the ServPPINs and with the diverse nature of innovation that are produced in service sectors i.e. ServPPINs types. The nature of the network actors, of the process of interactions and of social capital is expected to change with the change of innovation produced in the ServPPINs: technological and non-technological or complex innovation. For example, the degree centrality of public actors represented by universities and research centers in the ServPPINs for producing technological innovation is expected to be different from that for producing non-technological innovation, and the role of public in the crystallization stage is expected to be different from that in the consolidation stage.

Chapter 3: A conceptual framework for public private innovation networks: A technological perspective (TechPPINs)

Introduction

The second part of the last century has witnessed major changes in the form of public output provisions. Public organizations have faced major difficulties to provide their services because of the increase in cost and demand. In most developed countries, public budgets were no longer sufficient to face increasing demand for public services. In such a situation, collaboration with private organizations i.e. establishment of public-private partnerships (PPPs) was seen as a possible solution. In the PPPs,the private actors access to public actor resources and make new profits, while public actors can also transfer their risks to the private partners and exploit their experience and flexibility. Thus, both public and private actors have a common interest to be involved in cooperation relationships (PPPs).

Recently, collaboration between public and private actors has extended from production-oriented PPPs to include innovation-oriented PPPs (IPPPs) (Djellal and Gallouj, 2010c) and public-private innovation networks (PPINs). In these new concepts, public and private actors cooperate to access complementary cognitive resources (knowledge and technological resources, information, skills, know-how) and production and diffusion of innovation outputs are the main activity.

Organizations implement innovation activities to face the increasing demand for their innovative products and to stay competitive in high competitive economies. In modern economies, information, complex knowledge (like R&D), skills, competences, etc are the input resources for new innovation activities. The increasing complexity of knowledge and the technological environment linked to the globalization trend and the invasive character of the new informational paradigm are among the factors explaining the rise of innovation-oriented cooperation between public and private actors emerges (PPINs).

The cooperation between organisations for accessing, producing and diffusing new technological resources is not new. The last 20 years have experienced different forms of collaboration relationships that have been theorized for example, in terms of innovation system, innovation network and innovation cluster.

Here, we focus our discussion on technological PPINs (TechPPINs) i.e. networks which the main objectives are to mobilize complex knowledge and technology to produce new artefacts or technological innovation mainly in manufacturing sector. The TechPPINs evolve mainly as a specific application (form) of the traditional innovation systems and innovation networks (INs) (Freeman, 1987; Lundvall ed., 1992; Nelson, 1993; Freeman, 1995; Edquist ed., 1997; Hamdouch, 2009) (heavily discussed in the literature during the last 20 years), in which innovation activities are implemented in a social, interactive, systemic, complex framework.

The main focus in the literature is to account for efficient interaction processes between heterogeneous actors (public and private) to obtain an efficient innovation process that leads to new technological innovation outputs. In this chapter, we deal with this objective by formalizing a conceptual framework that contains the structural elements of the public private innovation networks (PPINs) that are required to design efficient innovation process. But before suggesting this framework, we briefly present an overview of the concepts of the PPPs and INs which are intensively discussed in the literature. This is important to define the PPINs structures and the factors that may lead to successful innovation process.

The first part of this chapter is devoted to the definition of PPP, their forms, their objectives and the nature of the complementary resources they can mobilize. In the second part, we discuss the evolution of the network concept to include both social and innovation networks. We also define the INs concept and discuss its motivations. In the third section, we display a conceptual framework forthe PPINs which includes the structural elements of the public private innovation networks (PPINs) and the innovation mechanism which lead to an efficient interaction process and a successful innovation output. Finally, we also discuss in section 3 the successful organizational and institutional changes required for having anefficient innovative process in the PPINs.

1. The concept and other important issues about PPPs

The PPPs have a long history in many countries. In the 1950s and 1960s, the federal government in the United States employed the PPPs in the development of inner-city infrastructures (Fosler and Berger, 1982; Fosler, 1986; Linder, 1999). They were introduced at the beginning of the 1980s, PPPs in Europe (mainly UK[5]) influenced by the successful models of PPPs in the USA (Geddes, 2005).

The PPPs are loose concepts and their boundaries are not fully determined. They lie between traditional public procurement (with no private sector involvement in public provision) and full privatization, and cover several models of cooperation relationships between public and private actors. In other words, the PPPs could be embedded in multiple forms (models) depending on the level of private involvement (participation)

[5] UK experience with PPPs was one of the first successful and most prominent in Europe. In 1979, UK government changes the high involvement of central government in the economic toward utilizing private capital (Bult-Spiering and Dewulf, 2006), and by the 1980s, PPPs became an explicit instrument for public sector. New systematic program named private finance initiative (PFI) was developed in 1990's aimed to encourage PPPs.

in the designated partnership. It may extend from businesses entirely controlled by the private sector at one end and to those almost entirely controlled by the public sector at the other end. Many scholars when mentioningthe PPPs don't specify which type of PPPs they refer to and the degree of private involvement.

There are multiple factors which determine the mode of PPPs, for example, the size of risk and its distribution pattern, the required degree of each partner's specialization, the formulation of the contract and the negotiation of its terms and consequences (Kanakoudis et al. 2007). In the first part, on the basis of a literature review, we will provide a definition of the PPPs concept, and discuss its motivations and determinants. This is important to understand the nature and structure of cooperation between public and private actors and distinguish it from other PPINs.

1.1. PPP concept

In the literature, PPPs do not have a specific definition. They are defined as a hybrid cooperation between public and private sector (Eichhorn, 1998), a form of cooperative venture between public and private firms (Moskalyk, 2008 and Kanakoudis et al. 2007), a contractual agreement between a public agency (federal, state or local) and a for-profit corporation (national council for PPPs) or a new way to design, build, finance and manage (operate) (DBFO) public building and infrastructures (Carassus, 2005). There are only small differences between these definitions. Most of them describe the PPP as a cooperation between private and public partners who seek to overcome the problem of budget constraint, share some of the risks and deliver a more cost-effective public product.

The PPPs are also associated with a new public management (NPM), where the lack of efficiency in traditional bureaucracy leads to the emergence of alternative management models to increase the efficiency and performance of public sector by adopting new management methods (Farazmand, 2001; Prahalad and Hamel, 1990). It is employed at both micro- and macro- levels (Hammerschmid, 2001). At the former, the NPM leads to basic changes in the role of the public actor represented by the state, local or global authorities, while at the latter, it leads to reforms in the internal organization of public authorities by the implementation of revised management concepts and tools. The NPM represents new forms of regulation and decentralizing of management within public services (Artadi, 2006), and distinguished by new governing models where the boundaries between public and private sectors have become blurred (Stoker, 1998).

Because of the PPPs, the role of the public actors develops from direct operators to organizers, regulators and controller of the outputs produced by the private partner. The private partners seek for satisfactory safeguards in order to reduce the commercial risk and to recover the costs of producing public products. They bring together a combination of interests that includes diverse range of skills from more than one sector to provide efficiently public products (Moskalyk, 2008).

1.2. Motivation for PPPs

Public organizations have an obligation to ensure that the large scale investment in public works is effective and can achieve improvements in social and economic performance (Shen et al., 2006). However in many countries, the traditional way of providing public services suffers from some distortions or deficiencies (e.g. high risk, inefficiency and inadequacies of finance). Therefore, throughthe PPPs, public organizations search for alternative sources to overcome these deficiencies, whereas the private organizations seek to enhance their business (economic) interests.

Here are the most well-known motivations for forming PPPs:

a. Limited resources

In some countries, due to the budgetary constraints and fiscal rules, public actors become incapable to provide their products and implement their projects through traditional procurement (OECD, 2008). Also, many of low-income countries experience fiscal crises in public expenditure, under-maintenance in existent infrastructure and underinvestment in new infrastructure. Consequently, public actors search for financial resources to face economic growth requirements, so they cooperate with private actors to overcome these budgetary constraints. Sadka (2006) adds that through the PPPs, public entities transfer present budget deficit into future budget deficit by spreading the amount of an investment over many future budget years.

b. Risk managing

The multi-dimensional projects in public sector lead to a wide range of risks that distribute all over projects' stages and life cycles. Therefore, alleviation of risk burden is one of the vital motives for the PPPs, where the risks associated with each component of the project will be identified and distributed between public and private actors depending on their degree of involvement in the partnership. Appropriate definition, analysis and allocation of risks are the keys to achieve value for money, while the failure is translated into financial costs (OECD, 2008).

The PPPs could be affected by different kinds of risks which are distributed at the micro- meso- and macro levels. For example, risks of shocks for products availability and quality, risks related to the construction and design phase, cost overruns, financial risk, demand risk, and performance risk (Hemming, 2006).To allocate these risks efficiently, Li et al. (2001) suggest that macro- level risks should be retained by the public sector; meso level risks should be transferred to the private sector; while micro-level risks should be shared between the two sectors.

c. Achieve a kind of collaborative advantage

The achievement of collaborative advantage is also one of the main arguments for establishing PPPs that are achieved when "something unusually creative is produced -perhaps an objective is met -that no single organization could have produced and when each organization through the collaboration is able to achieve its own objectives better than it could alone" (Huxham, 1993). Collaborative advantage enables all parties to build common trust, enhances communication skills, facilitates interactive communication and social interaction and raises effectiveness. It also leads to synergies between parties through pooling of expertise, common resources and skills, and bringing together the strengths of diverse backgrounds for the public goods (Moskalyk, 2008).

1.3. The PPPs forms

The PPPs have different forms depending on many factors such as number and involvement of public and private actors involved in the partnerships, the objectives and duration of PPPs, etc. Here we only define the three main well-known types of PPPs (Kanakoudis et al., 2007; Bennett and Iossa, 2006): joint venture, concession and hybrid.

Joint venture is established between public and private sectors to undertake a strategic role in the planning of public goods provision (Bennett and Iossa, 2006). Public and private organizations assume co-responsibility and co-ownership for the delivery of output. Thus, risks, reward and total project budget are shared between them. The private sector is often responsible for performing the daily project management, whereas the public is the ultimate regulator.

Under concession, the private contractor is responsible for the delivery of public products. This includes any capital investments required to build, upgrade, or expand the system (Bennett et al., 1999), and all related operation, maintenance, collection and management activities. He also determines the pricing policy, managing commercial risk, collecting the money from the users of the services provided and paying an amount of money to the public partner (Kanakoudis et al. 2007). The public sector is mainly involved in regulating price and quantity, determining performance standards and ensuring that the private contractor meets them.

Finally, hybrid is represented by three main models depending on the task devoted to private actors: build, operate and transfer (B.O.T), operation and maintenance (O.M) and operation, maintenance and management (O.M.M) (Kanakoudis et al. 2007).

1.4. Other notions close to PPPs

Despite the large debate on the PPPs, collaboration between public and private is not limited on PPPs. We can find collaboration relationships between public and private actors unfolded in the PPPs. For example, public actors can enter in a long-term arrangement/relationship for certain kinds of projects (for example, multi-dimensional projects like transportation and tourism) with more than one private company (consortium of private firms) (Jost et al. 2005). Boase (2000) classified four types of partnerships between the public and private sectors depending on the power-sharing arrangements or relative influence on decision-making: consultative arrangements, contributorypartnerships, operational or community development partnerships and substantive partnerships. The PPPs can be found in one or more of these partnerships if real power sharing, joint responsibility for decision-making, provision of resources and shared risks and goals are found. Networks are another important and well-known cooperative relationship that might include public and private actors to build new business relationships.

2. INs and PPINs

The evolution from the PPPs to INs means a shift from cost perspective, new institutional arrangements, etc. (in the case of PPPs) to knowledge-based perspective of evolutionary economics in the case of the INs.

The PPINs are one type of the INs, in which public and private actors are included as main actors in the INs. In other words, they are defined explicitly as the main constituent elements, mobilizing complementary resources to develop new innovation outputs.

2.1. The IN concept

Thenetwork notion has multidisciplinary applications, as it is used in sociology, anthropology, human geography and organizational theories for example. Therefore, there is no consensus about one single definition for the notion. Moreover, network is a powerful analytical method to discuss the characteristics of various economic phenomena, such as regional agglomerations of economic agents and the user-producer relations in the supply chains (Debresson et Amesse, 1991).

The network is defined as a group of actors (individuals, organizations) connected by a certain type of relationships (Joy, 1964; Iacobucci, 1996). Gipouloux (2000) determines four main elements that constitute the structure and the operation mode of a network: 1) actors; 2) resources that represent the main exchange items between network' actors; 3) a binding mechanism which aims at providing coherence to the network (like license agreement, shares in equity and subcontracting agreement); 4) activities which include the outcome of the network.

Since the 1990s, innovation is one of the most prominent activity where the networks are applied successfully (Debresson et Amesse, 1991; Rothwell, 1996; Powell et al., 1996; Williamson, 1996; Kumaresan et Miyazaki, 1999 and Kuppers et Pyka, 2002). The INsare the most important application of the non-linear (open) model of innovation and they constitute a sustainable way in accessing external knowledge and technological resources which are required in order to produce innovations in today's environment.

The INs consist of several actors collaborating in a social, dynamic and economic environment. This leads to "an intensive communication and collaboration between different actors, private firms, and other organizations such as universities, innovation centers, educational and financing institutions, standard setting bodies, industry associations, and government agencies"(Toedtling and Trippl, 2005). The communications between network actors assure the diffusion and production of innovation output. Kuppers and Pyka (2002) define the INs concept by the three key following characteristics: 1) they form a coordination device where intercompany learning are enabled. 2) They provide complementary resources which are vital to the production of technological solutions. 3) They provide synergies between network actors by mobilizing different technological competences.

The INs are new organizational forms that replace the firms as dominant actors in the knowledge-based economy (Belussi and Arcangeli, 1998). In other words, they represent a locus where they "provide timely access to knowledge and resources that are otherwise unavailable" (Powell et al. 1996). Thus, to capture the main characteristics of the INs (e.g. inter-firm learning, the exploitation of complementarities and the creation of synergies), it is important not only to focus on cost-perspective, but also to rely on the knowledge-based perspective of evolutionary economics (Pyka, 1999) and to discuss the INs through the intersection between organizational learning and knowledge-based view (Thijssen et al. 2004).

The concept of INs is "often shadowed by the recent evolution of the innovation systems concepts[6]" (Pellegrin et al. 2010), which are considered to be broader perspectives or concepts. The concept of innovation systems (ISs) is discussed in the works of Lundvall (1988; 1992), Nelson (1993) and Edquist (1997) among others. For example, Edquist (1997) defined a system of innovation as "all important economic, social, political, organizational, and other factors that influence the development, diffusion, and use of innovations". Nelson (1993), for its part, defined a national innovation system as "a set of institutions whose interactions determine the innovative performance of national firms".

The concept of innovation clusters belongs to the same systemic and network tradition. They are special types of INs that entail interactive or collaborative processes of innovation in systemic and spatial frameworks (Hamdouch, 2009). They also require multi-agent collaborative relationships, where variety of actors (like, organizations, public institutions, suppliers) interact together and exchange knowledge, technologies,

[6] The "innovation system"(national, regional, sectoral) is abroad concept that includes many of the ideas contained in other interactive innovation concepts such as, networks, clusters development blocks, complexes, innovation milieu, complex products and systems, competence blocs (Manely, 2002).

skills and competencies in respective geographical localizations that occur at a variable spatial space and specific institutional environments to produce different modes of innovation (Hamdouch, 2009).

2.2. Motivation of INs

Rapid globalization, convergence of consumer preferences, high competition for limited scientific resources (Tushman, 2004), intensive and permanent changes in technologies- spurred by great scientific advances (Aubert, 2004) and new complex technological paradigms-stemming from advances in information and communication technologies (ICTs)- have led to organizational and structural deficiencies. Local connections in innovative organizations are not able to reformulate their competitive skills, provide solely the resources and competences required to offset high costs and keep pace with new technologies. This leads to a reduction in the sustainability of the innovation processes and to a major difficulty for innovation to occur without having global connections to exchange knowledge and information with the surrounded environment.

Thus, new changes in the organizing principles of economic activities and the enlargement of the organizations' boundaries to access a wide range of corporate expertise and technological fields are required (Castells, 1996 and Cantwell and Santangelo, 2006). This also requires the shift of the innovation processfrom a traditional perspective to a more system-centered approach that mainly depends on collaboration between public and private actors i.e. the replacement of the linear model of innovation by a non-linear one that presents the innovation process as "systemic, complex, multi-level, multi-temporal and employ a plurality of heterogeneous economic agents" (Lundvall 1988; 1992, Freeman 1988; Nelson 1988; 1993; Rossi et al. 2009). For example, in the promotion of INs in the agricultural sector, Hartwich and Scheidegger (2010) consider that "having single providers of knowledge and technologies, such as governmental extension services, advisory service agencies of development cooperation or the NGOs, may not be enough. There are also other important players that mobilize the innovation process and influence farmers in their decision to improve their operations. These players include buyers, sellers of agricultural inputs, providers of financial services, leading producers, farmers' associations, community groups, traditional authorities and many others. And it is often the repeated and joint effort of all these agents which motivate farmers to innovate".

The concept of INs has mainly been developed on the basis of technological innovation in manufacturing firms. In other words, the technological description of innovation in manufacturing leads to technological insight about INs. In this context, the strongest motivation for the formation of INs is likely to be the complexity of knowledge and technologies (equipments, research methods and techniques, simulation and prototyping, besides the technological knowledge itself) that are crucial to innovate in many industries (e.g. nanotechnologies and biotechnologies) which find themselves unable to carried out their technological activities successfully depending only on their internal resources. Kaasa (2007) also considers that innovation -mainly in high technological manufacturing sectors- is highly dependent on complex and specific knowledge. But many organizations cannot provide their innovation activities using internal connections, and so specialization and more complex technologies demand more cooperation.

Despite they have some similar structures to the PPPs strategic alliances, etc the INs have major differences compared to them in regards to the objectives. In the PPPs, economic objectives (e.g. complement financial resources, lowering risks and costs) are the more important, while in INs, more cognitive and technological objectives are emphasized, for example, the research for complementary knowledge and technologies, lowering the cost and risks of a new field of knowledge development, reduction of innovation uncertainties (uncertainty connected to the innovation appropriation and acceptance of innovation) and reducing the asymmetry of market information. Pellegrin et al. (2010) confirms that the interactions between actors in the INs change from a commercial, financial and productive nature to "cover a wide spectrum that goes far beyond market relations and contractual relations of cooperation".

2.3. PPINs

Most of the INs discussions highlight the role of private industrial organizations as the main constituent elements of the network. But, the analysis of innovation in a particular system may require considering the effect of interactions between industry, government and academia i.e. both public and private actors in the development of innovation (Manley, 2002). For example, Buesa et al. (2006) indicates that regional innovation system includes both public and private actors in one network and specific area to adopt and produce new knowledge. In many INs, the public actors may present in the realms of public innovation policy (Edquist and McKelvey, 2000), to support and enhance the innovation activities.

Most of INs are complex networks involving complex knowledge, sophisticated innovation practices and producing a technological innovation. A significant part of the complex knowledge and R&D resources needed could be acquired through universities, research centers and R&D institutions which are mainly provided by public organizations. Thus,the public role is becoming vital for the success of these technological INs.

The organizational and institutional competences (e.g. the taxation system, the education system, the internal structure of government bodies, the structure of the state and its policies, regulations, legal competences, standards and routines that public bodies can provide are also necessary for efficient and successful interaction process between INs actors (Manely, 2002).

Technological public-private innovation networks (TechPPINs), are collaborations between public and private actors in which the innovation outputs are mainly embodied into technological artifacts. This concept aims to re-formalize the INs to highlight the specific roles of public and private organizations in the innovation process, and the way these roles evolve along the INs life cycle. In this TechPPINs, new knowledge channels and flows are included which mainly pass through the public actors.

The technological capabilities of public and private actors are likely to include both internally developed technologies and that developed out of firms' boundaries. Internal and external technological capabilities are complements not substitutes to each other (Powell et al 1996). While external collaboration allows to access resources which are not available internally since internal capability (e.g. internal R&D) is important to evaluate and absorb the external resources (Saviotti, 1998).

TheTechPPINs are described as "traditional' INs. This is relevant to their focus on providing technological innovation mainly in manufacturing sector. The TechPPINs neglect the fact that INs can be constructed to produce non-technical innovations, which is frequent in service sectors. Examples of traditional PPINs are very numerous mainly in industrial sector. For example, in Germany, Musiolik and Markard (2010) describe a PPIN formed between fuel cell industry and federal governments to speed up the technology development and market formation for fuel cells. Markard and Truffer (2008) used the technological system of innovation, to show the importance of collaboration between public and private agents in the generation, diffusion and utilization of different modes of technologies and/or products. The EMC innovation network is also a prominent example, where research and advanced technology groups across EMC, universities and RSA laboratories collaborate to discover and explore technologies that will shape the information infrastructure of the future.

3. The construction of aTechPPINs conceptual framework

The construction of a TechPPINs conceptual framework is a theoretical attempt to explain the cooperation and configuration of TechPPINs, and to analyze the innovation processes as the outcome of collaborative networks between heterogeneous public and private actors to produce new technological outputs. This theoretical perspective corresponds to a general theory bridging insights of other specific theories like evolutionary theory, social network theory, life cycle theory, etc.

The conceptual framework will function as a mediation framework and coordination mechanism that expresses the dynamic process between TechPPINs actors to ensure successful and efficient technological innovation outputs. Empirically, this conceptual framework can be applied to describe the innovation processes in actual TechPPINs.
The conceptual framework is based on four basic elements. First, it will take into account the high heterogeneity of TechPPINs i.e. the inclusion of public and private actors as main factors interacting in technology creation and diffusion. Second, the process of interactions between different actors is a dynamic and evolutionary process, which is responsible for the network formation (structure) overtime. Third, the processes of ties decoupling and fragmentation are combined with the emergence and development of social network which is likely to generate knowledge disclosure between network actors to stimulate different forms of innovations. In other words, innovation processes respond to the social interactions to produce successful innovation outputs. Finally, the innovation network has an evolutionary path (life cycle). In each stage of the life cycle, new interactions are re-arranged to construct the network structure overtime.

The theoretical background supporting the construction of the conceptual framework derives not only from economics, but also management and social science. For example,interactive learning theory is important to capture the interactive processes between heterogeneous actors in a network, while the evolutionary economic theory is important to describe the interaction processes between different actors and dynamic processes of knowledge accumulation and diffusion. Both of Social network and structuration theories are important to show that networks are constructed into the social processes presented in the network and that these social processes are essential to the relationship founding and first stage performance. New institutional theory and organizational theory are useful to capture the institutional and organizational changes employed in the innovation processes.

3.1. Public actors' role in TechPPINs

The presence of public actors as major participants in the innovation processes adds new complexity to the interaction processes. Therefore, it is important to know how they interact in technology production and diffusion. As we discussed previously, public actors mainly involved in the technological innovation processes. Therefore, universities and public research centers and R&D institutions are important public participants because of their internal complex knowledge and technological capabilities. Nevertheless, the public role and participation do differ from one PPIN to another, depending on the complexity degree of the network, power-sharing arrangements between the public and private actors or relative-influence on the innovation.

In the TechPPINs, public actors can also provide a non-R&D knowledge when functioning as intermediate organizations which provide institutional arrangements which are required for managing conflicts, regulating the relations (cooperation) and improving the coordination mechanism between network actors. These institutional competences include new rules, routines, approaches, legal and government policies, new types of intervention tools, design of political initiatives which are adequate to foster the learning and knowledge exchanging processes and supporting functions that ensure the cross-flows of knowledge and information between other network actors.

The presence of heterogeneous actors with complementary resources is essential but it is not enough for efficient innovation process. Connectivity (interrelations) is essential for the mobilization and exchange of technological resources between public and private actors. For example, Nauwelaers and Wintjes (2008) indicate that some innovation networks "consist of firms grouped under specific areas of activity, but lacking the depth of linkages and inter-relationships that are necessary for grasping many of the static and dynamic cluster benefits". It is important to adjust the interrelation (interaction) processes between public and private actors -they generally have different preferences and competences- in a way that avoids the inconsistency between their preferences and their technological capabilities.

3.2. The social dimension of TechPPINs

The INs function represents important modes of social interactions. The decoupling and fragmentation of ties (interactions) between network actors are combined simultaneously with the development of social network (Agapitova, 2003). Therefore, TechPPINs are constructed also into the social processes presented in the networks (Samli and Bahn, 1992). In other words, the structure of TechPPINs is a result of a social action and the production of technological innovations occur in social interactions.

The social capital in TechPPINs enhances the collective learning between heterogeneous actors and impacts the exchange behavior (Granovetter, 1985; Uzzi, 1997; Valley et al., 1995). In a causal mechanism related to innovation, the social proximity has an impact on knowledge spillovers (Coulon, 2005). Consequently, the technical and economic factors alone are not efficient to explain social interactions process in TechPPINs. A socio-economic framework (regime) is important to incorporate both technological and social dimensions of interaction processes.

Social processes are gaining more interest in TechPPINs because interactions between network actors (network structure) strongly determine the innovative output. Therefore, social capital has an important role in relationship founding, first stage performance, and in maintaining the cooperation between network actors in the long-run. They are also important to balance the deficiency when using economic dimensions to describe social entities, mainly using physical artifacts and the corresponding R&D and economic activities to describe the different stages of life cycle of TechPPINs product (Pyka et al. 2010).

Social network analysis (SNA) (Freeman 1984) is one of the most prominent techniques used to incorporate social dimensions, analyze social relations between individual firms or actors (Salavisa, 2009), shape the evolution of innovation in innovation networks and to determine the position receptivity or popularity of network actors (Wasserman & Faust, 1994). One of the most important aspects of the SNA is the focus on both network structure and actor-diversity to interpret behavior (Coulon, 2005).

The SNA has metrics (measures) that can identify network characteristics from both actor-related and network-related levels. Actor-related measures (like, degree centrality and closeness) are used to describe the role, power and influence of different actors in the process of exchange, creation and diffusion of new knowledge and technologies. Network-related measures (like density, clustering coefficient) are important to provide an overall measurement for network characteristics regardless of the actor-level assessment. They are important in determination of the evolution of innovation network, and they show other important factors related to the innovation process like, the stability of network (more density network lead to more stable network), the speed and number of channels for information flow (high connectivity provide different ways for knowledge diffusion).

Many scholars in innovation network discussion employed SNA. For example, Messica (2007) in a static analysis of innovation network in high-technology sector used three SNA metrics like, clustering coefficient, the extent of the network and the mean connectivity to provide an IN’s taxonomy. He classified INs into five categories: ring, mesh, star, fully connected and line. Cowan et al. (2004) in dynamic analysis of innovation networks, used different SNA metrics like, local order or cliquishness, path lengths and density. They found that knowledge creation through emerging network was the corner stone of the innovation process. Watts (2003) used distance between nodes to estimate the effect of network structure and actors’ behavior. Pyka et al. (2010) in their analysis of innovation network, classified SNA measures into two groups. The first group includes actor related measures: degree centrality, closeness centrality and betweenness centrality. The second group includes network-related measures to describe the structure of the whole network: density, connectivity, distance, degree distribution and clustering.

3.3. The dynamics of TechPPINs

In TechPPINs, the innovation performance is determined not only by the characteristic of the actors but it also depends on the interactions or relations between them. The interaction or communication processes between network actors are not static. They are dynamic or evolutionary processes (Arechavala-Vargas et al. 2009) associated with ties decoupling and fragmentation processes (i.e. the entry of new actors and exit of others or forming of new ties and dissolving of others). Therefore, innovation in TechPPINs is likely to be described and explained in the spirit of evolutionary theory (Nelson and Winter, 1973) and path dependence theories (David, 1985).

Dynamic innovation network means that the state of the network in one period determines its state in subsequent periods. Therefore, the initial form of the network has a fundamental role in the evolution of the network at later stages. It determines its final structure. A network may start spontaneously with informal interactions between actors where the entrepreneurs play a vital role in making the network function and develop the innovation in the initial stage. Then, at later stages, it may evolve towards a permanent network and become more professional in terms of internal management and development of learning and provision of a sustainable innovation (Weber, 2009).

The dynamic processes are important as they induce knowledge accumulation and learning overtime (Garcia-Pont and Nohria, 2002; Gulati, 1999; Powell et. al 1996) and allow to access new technologies that promote innovation output. Dynamic process in TechPPINs leads to different structures with different roles over time. An efficient dynamic process matches between two network specificities: the enormous complexity of the interaction patterns and different incentives and information that determine the behavior and preferences of actors (Schweitzer et al. 2009).

Topologically, it is expected that the conceptual framework for the PPIN considers both the dynamic process of interactions and the structure of the network, because different evolution rules lead to different network topologies.

3.4. Life cycle growth model for TechPPINs

The dynamic process of PPIN is systematic. It is important to have a theoretical concept to explain the network function and success factors, redefine actors' roles over time and distinguish between different networks and show how the structure of INs change or evolve overtime arriving to an efficient state,

In the literature, we can find many approaches to describe the dynamic of the network. Li (2005) proposed a socio-cognitive model for newly development products illustrating the dynamic of interaction between technological platform/hard architecture of knowledge and communities/soft architecture of knowledge that lead to open innovative and new products. Podolny et al. (1996) used niches in evolutionary theories of technological network (technological network niches). Weber (2009) proposed another theoretical model that explains the network life cycle using chaos theory and cybernetics for public-private network.

Network life-cycle growth model was found to be the most prominent theoretical concept that is used to take into account the growth of network (Jovanovic, 1994; Klepper, 1996, 1997; Weber, 2009 and Pyka et al., 2010). It consists mainly of three main stages: prototype-industry, commercialization and entrepreneurial, and consolidation and firm growth (see table 1). The INs evolves through life cycle model where each stage is characterized by different knowledge bases, types of resources, of network actors, of demand and of policy. Different modes of interactions between network actors (i.e. the exchanged knowledge to produce output "X" will certainly be different from that of producing output "Y") are also expected in each stage.

Two important points should be considered when applying product cycle growth model to TechPPIN. First, the social dimensions that are important in the formation of TechPPIN should be considered. Mainly, the introduction of "a socio-economic approach" that consists of both economic measures (relative performance) and relevant social indicators (measures) allow the product life cycle growth model to incorporate the social dimensions of interaction process (Cowan, 2004; Koenig et al. 2007 and

Pyka et al., 2010). Second, it is difficult to follow the whole life cycle stages in some forms of TechPPIN. This may be explained by the disappearance of the network before the decline state, the start of a new cycle within the same network (Tushman and Anderson, 1986). In some other cases, the network may follow more than one evolutionary path (Weber, 2009).

Table 1: Stages in the life cycle of public-private networks (source: ServPPIN project)

Dimensions / Stages	**Knowledge base**	**Resources**	**Network membership**	**Demand**	**Policy**
Proto-industry stage crystallization stage	Specific and scattered (geographically and institutionally)	Public funding	Universities and government research institutes	No articulated demand	Geographically and technologically scattered; mission-oriented
Commercialisation and entrepreneurial stage	Specialised knowledge / local diffusion leading to regional competence clusters	Venture capital funding and resources provided by large (established) firms in order to get access to new knowledge	Private firms (often start-ups) enter the networks or found own networks, large participation of public actors	First articulation of demand with a large adjustment gap between potential demand and instant demand	Cluster-oriented, regulation (providing legal framework supporting knowledge diffusion); diffusion-oriented
Consolidation and firm growth phase	New knowledge becomes paradigmatic for the industry	Venture capital is rolled back; internal funding and entrepreneurship become dominant	Declining participation of public actors	Well articulated demand generating revenue streams for innovative successful firms	Regulatory regimes and anti-trust

3.5. Institutional and organizational dimensions of conceptual framework

Organizational deficiencies and weak building of institutional framework are two main network failures. Transformation from a closed notion of innovation process (innovation is a decision of one actor) to an open process of innovation (innovation output is a result of collaborative effort of several actors) entails decisive path-shifting in terms of organizational and institutional patterns to form a supportive instrument for the innovation process and avoid any possible contradictory forces between the heterogeneous preferences and competences of network actors, which if not handled appropriately might lead to the emergence of lock-in forms of innovations. Consequently, establishing an efficient institutional and organizational system in TechPPINs is essential to operate in a flexible manner along the network life cycle. Indeed, inappropriate organizational changes and divergent orientation of existing institutions at one stage may lead to serious innovation problems at other stages.

In fact, organizational changes constitute a path parallel to the network life cycle growth model. Organizational competences are developed to cope with the creation and diffusion of new knowledge and technologies along the network life cycle. The shift from one stage to another requires the shift in the organizational patterns to organize the behavior of actors and the interactions between them.

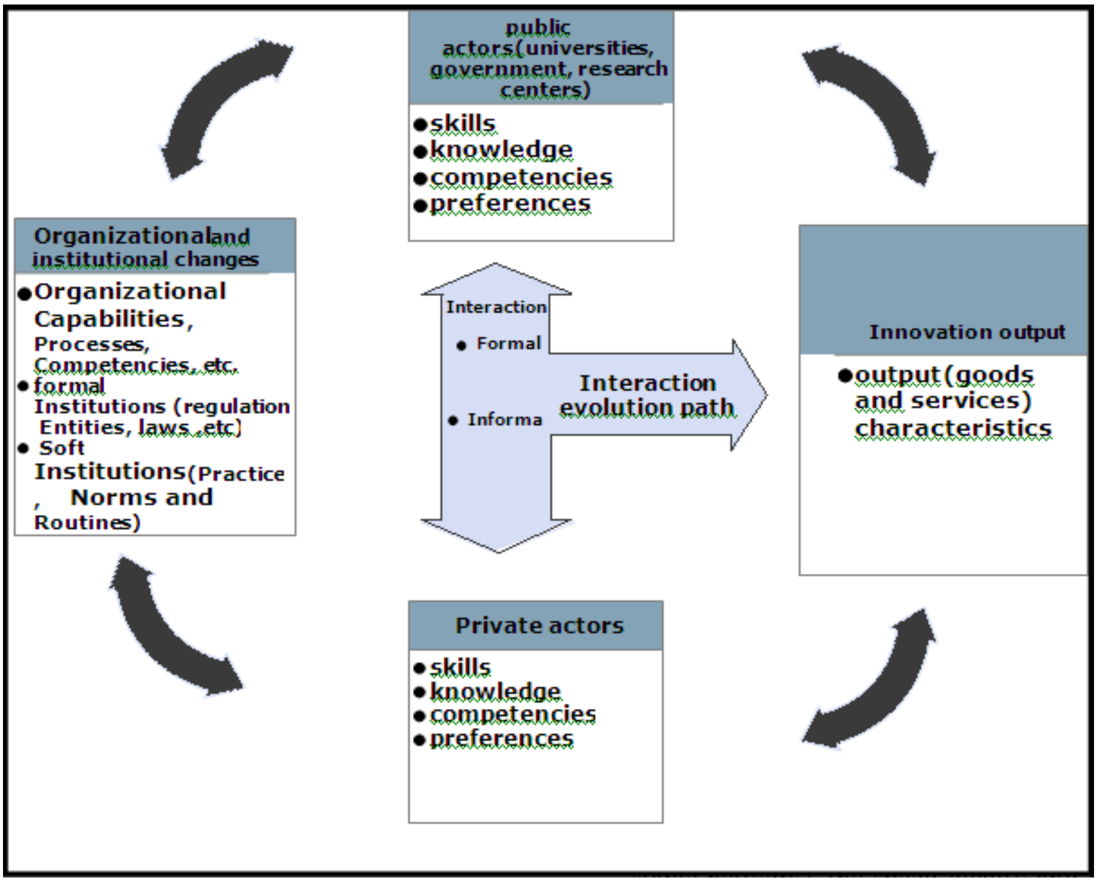
The process of innovation and institutional adaptation are two interactive entities in the PPIN structures. The institutional competences in the PPIN serve as a medium where knowledge and technologies are combined with routines, norms, rules, regulations and mutual understandings to facilitate the process of interactions and to have an efficient exchange of information between network actors. They allow the PPIN to survive and act in a high changeable and an uncertain informational and technological system, by safeguarding the mutual relationships and securing the flow of knowledge and technologies between different actors and determining the factors that may impact on fostering or constraining the innovation processes.

Institutional adaptation includes wide varieties of practices which are provided by public institutions, private institutions or from individuals. They might comprise funding organizations (banks, venture capital companies, ‘business angels’, public funding agencies, etc.), law companies (especially those specialized in property rights issues) and regulation entities (standardization committees, ethical commissions, etc.)(Hamdouch, 2009).

3.6. A conceptual framework for TechPPINs

The TechPPIN framework is defined by the articulation of the four constituent elements discussed in the previous paragraphs in an open, complex, social and interactive process of innovation. Figure 1 shows how public and private actors interact dynamically in the product life cycle model, reinforced by social capital and supported by appropriate institutional and organizational changes to facilitate the process of interactions so as to produce efficient and successful innovation process.

Figure 1: PPIN conceptual Framework



In this conceptual framework the innovation output is provided as follows: the public and private actors communicate and interact between each other. Complex knowledge and technologies are exchanged between them in a collaborative environment and supported by the social capital, to produce new technological innovation. The complementarities between actors' knowledge and technological resources are crucial for successful and efficient interaction processes. The interaction processes and the production of innovation output are dynamic processes along the network life cycle. In each stage of the network life cycle, the nature of the interaction processes and innovation activities are different (the mode of innovation in the first stage of network formation is different from that at the growth or maturity stage), determined by the type of actors, the SNA dimensions and the mode of knowledge and technologies exchanged. The diversity of innovation activities along the evolutionary path is critical underpinning for a successful PPIN life cycle.

Following the network life cycle growth model described in table 1, we expect that in the crystallization stage the role of public actors represented by universities and public research centers is important for the initiation of innovation networks. No demand articulated yet in this stage, and the participation of private organizations is not high. In regards with SNA, the enabling power is focused on the public actors who control the flow of cognitive resources through the network.

The dynamic process of the TechPPINs allows for the transition from the initial to the commercialization stage of the network life cycle, and it shows how the competences and preferences of one actor co-evolve overtime with the competences and preferences of the other network actors supported by a “feedback mechanism”. Network actors either reinforce each other to produce and diffuse new technological resources or conversely hamper each other.

The first articulation of demand occurs in the commercialization stage with a large adjustment between the potential and instant demand. New actors enter the networks mainly private ones for the marketing of the new technology. Large public actors’ participation still exists in this stage. SNA also changes in this stage. SNA are important to explain how innovation network safeguards continue the process of knowledge and technologies flowing between the network and newcomer actors, and also define the public and private actors’ roles in the innovation process. Here, the public actors may not keep the enabling power because new private actors enter the network and may have important role in the produce and diffuse of cognitive resources. This is expressed by the distribution of degree centrality between public and private actors. Here also, intensive interactions (high network density) are important for quick diffusion of cognitive resources between the public actors -who are main source of complex knowledge- and private actors who need this knowledge to develop their innovation output. Private actors can also be an important source for complex knowledge through internal R&D activities, and therefore could exchange with public organizations. The innovation produced might be radical either to the market or to the network actors.

If there are no technological discontinuities or inconsistency between the exchanged cognitive resources then the TechPPINs will grow to the consolidation stage. At this stage, there is a decline in the participation of the public actors, well articulation of demand and technological standards increase. High entry is expected in this stage, and demand for innovation outputs attracts new private firms which realize the business opportunities- to enter the network. The innovation produced in this case might not be new to the market. It may be new to the network members, incremental innovation or improvement innovation. Thus, the radicalism of knowledge and technological resources produced and diffused in this case are less than that in the crystallization and commercialization stages. At the end of this stage, because of the high competition between firms, the number of entrants firms may reach its peak.

The key role or control power in the innovation process is re-defined to be owned by private firms. More interactions (connectivity) between the private firms are important in this case to exchange their cognitive resource. Because of the decrease in the role of new knowledge and technology (R&D), the connectivity between public actors (universities and public research centers) and private firms is less important than the last stage.

Conclusion

In this chapter, we have developed a conceptual framework to account for traditional TechPPINs. This framework accounts for the cooperation between public and private actors in a complex, dynamic, social and interactive network structure. In such a framework, innovation output is produced through dynamic interaction processes between the public and private actors along the network life cycle. In each stage, various interactions occur and different modes and various quantities of knowledge and technological resources are exchanged reinforced by the existence of social capital. The combination of the product life cycle model and the SNA allows to analyze the structure of TechPPINs at each stage of the life cycle and to reveal important information about how public and private actors' roles are embodied through network life cycle. Organizational and institutional changes are important for the efficient construction of TechPPINs. They facilitate the initiation of collaboration between PPIN actors, the exchange of knowledge and competences in all stages of network life cycle, and they avoid any prospect conflict between heterogeneous preferences and competences of network actors.

In the next chapter, this conceptual framework will be applied to non-traditional PPINs where public and private actors are to produce service innovations (ServPPINs). The conceptual framework will be adapted to take into account the service nature of innovations and also the different types of ServPPINs that may exist.

Chapter 4: A Conceptual Framework for Public-Private Innovation Networks in Services (ServPPINs)

Introduction

Public and private actors cooperate to produce an innovation output not only in manufacturing, but also in services. Therefore the purpose of such cooperation may be non technological innovation in its various forms.

Innovation networks (INs) in service sectors are sometimes addressed in the literature but mainly when their objective is a technological innovation. The role that public-private-innovation networks (PPINs) can play in the production of invisible and non-technological innovations in services is under-estimated. In other words, there is a gap in the literature regarding the discussion of the INs in service sectors. This is consistent with the underestimation until recent time with the innovation in services. Therefore, public-private innovation networks in services (ServPPINs) are not well known as an economic reality and not well established as an economic concept.

Due to their technological and industrialist bias, traditional INs and technological public-private innovation networks (TechPPINs) do not address innovation activities that are non-technological, disembodied or invisible like service-based innovation activities (e.g. organizational approaches, methods and procedures, new solutions and new designs). Therefore, it is necessary to develop our discussion about the INs in order to incorporate special type of cooperation relationships where public and private organizations cooperate to produce new service innovations.

This chapter explores the concept of innovation in services and aims at providing a conceptual framework for ServPPINs. The debate will be focused on how the conceptual framework of TechPPINs is likely to function when the production of service innovation is the core activity. In other words, it will show how the foundation concepts that drive the TechPPINs conceptual framework (actors, interaction processes and exchanged resources) are likely to be adapted (adjusted) to incorporate service innovation (technological and non-technological). This work is expected to contribute both to the research about network paradigm and innovation in services.

The discussion is organized as follows. In the first part, we discuss the cooperation as a success factor for innovation in services. We also argue the deficiencies of traditional INs, which lead to new concept of INs in services (ServPPINs). The ServPPINs motivations, the nature of innovation they produce and the differences of actors' roles are also discussed. A taxonomy for the ServPPINs types is discussed, which depends on the fact that in services both technological and non-technological innovations are important outputs which are adopted from outside the network or/and internally produced through interaction between network actors. In the second part, we adapt the conceptual framework of TechPPINs to service activities. In regards with each type of ServPPINs, we will discuss different innovation processes under the conceptual framework, depending on social and economic interactions between public and private actors along the life cycle growth model.

1.The PPINs in service sector

The shift of the discussion from the TechPPINs to the ServPPINs requires the highlighting of some important points that help in determining the types of ServPPINs and associated conceptual frameworks. Firstly, we discuss how the cooperation can be a successful policy for prompting innovation in services, like it is in the manufacturing sector. Secondly, we show the deficiencies of the traditional INs in services. Thirdly, concept and motivation of ServPPINs is different from that in TechPPINs mainly in the objective of cooperation and the nature of mobilized cognitive resources. Fourthly, the innovation activities in ServPPINs are not homogeneous; they diverse between technological or non-technological, adopted or produced and planned or unplanned. Thus, we expect different types of ServPPINs.

1.1. Cooperation as a policy to prompt innovation in services

The positive association between innovation in services and economic performance confirms the need to enhance or foster innovation in services through adopting new strategies or policies that prompt innovations, either by innovative organizations or governments. One of those strategies is the organizations shift from linear to complex model of innovation in which innovation is provided through complementarity between skills, competences, knowledge and technologies of more than one partner i.e. by in collaborative structure between more than one organizations.

The European Union policy also favors new forms of knowledge diffusion and networking between service firms and other research sources, and innovation clusters on the sectoral level which lead to new service outputs through “developing and promoting new technology-based services in close partnerships between larger firms, universities, innovative SMEs and local user groups” (SEC, 2009). OECD (2005) also introduces different policies for prompting innovation in services, where networking is considered one of the most important patterns.

Another challenge that prompts innovation in services is the shorter product life cycles for many service outputs which lead to the need for an interactive model of innovation, in which innovation is a result of the collective efforts of several actors. Furthermore, the nature of the production process and especially the co-terminality of production and consumption confirms the cooperative dimension of the innovation in services. Therefore, service firms are more likely to cooperate in supply-chain (consumers and producers) than manufacturing firms which rely heavily on internal R&D activities

(Laursen and Salter, 2006). In other words, manufacturing firms focus on 'physical technologies', while service firms focus on 'social technologies' in their innovation activities (Nelson and Sampat, 2001). These interactive innovations in services are coupled with the development of organizational arrangements which facilitate the interactive process.

1.2. Deficiencies of traditional INs

Djellal and Gallouj (2010c) denote three main weakness of the traditional INs. 1) They are technology-biased i.e. they focus in producing and diffusing technological innovation. This will affect the public innovation policy to promote innovation that will also be technology-biased. 2) INs are also manufacturing-biased. As we are talking about technological innovation, then manufacturing is the focus sector. 3) INs have some degree of market biased, through the central role of private actors in the formation and developing of INs. The structure of INs, role of actors and the nature of interactions are expected to be different when non-technological innovation activities are in the core of cooperation between public and private actors.

Therefore, it is important to abandon traditional view of INs, and to adopt more comprehensive perspective of innovation networks. In this new perspective, not only technological innovation activities are captured, but also non-technological innovation (e.g. organization innovation, market innovation, ad-hoc innovation, social innovation). In other words, it is important that the discussion of INs in services breaks the traditional INs, in which complex knowledge (mainly R&D) is the main objective of cooperation.

1.3. The definition of ServPPINs and their motivations

The ServPPIN concept is similar to TechPPINs with regard to the public-private involvement. Thus, it is also defined as cooperation relationships between plurality of public and private organisations to produce a new innovation output. However, in the

ServPPINs, the focus of innovation is enlarged to encompass both technological and non-technological innovations (service-based innovation).

Sundbo (2009) defines ServPPINs as "a network (that) involves the coming together of actors: their interactions will result in a redefinition of roles over time". The interaction between public and private actors,[7] social relations and the evolution (dynamic) of network are important features. Sundbo adds that innovations are the result of collective efforts and could have different forms i.e. they might be technology-intensive as well as primarily organizational, and "can range from (formerly) public services that are now provided in a public-private arrangement to private services supporting public service".

The rise of ServPPINs may be explained by conditions similar to that of TechPPINs: rapid globalization spurred by the high development of telecommunication sector, convergence of consumer preferences, increase of development time, high competition for limited scientific knowledge, organizational and structural deficiencies result from advances in information and communication technologies. These conditions lead to the formation in services of integrative models of innovation like the TechPPINs in manufacturing sector.

However, there are also some service-based motivations for the rise of ServPPINs. First, in services, the life cycles of service outputs are shortening for most of service outputs. Therefore it has become difficult to earn the profit from new innovation output before they are copied by other organizations. Second, the service production depends highly on skills and competences of high experience and skill human capital. Third, new management or marketing techniques, the adoption of new supply or logistic arrangements, and improved approaches to internal and external communications and positioning and solutions are more essential than technological innovation (e.g. product, process) regarding innovation in services. Looise and Van

[7] The networks could also include 'third sector' organisations (charities, non-government organisations NGOs (Sundbo,2009).

Riemsdij (2004) indicate that "a more effective organization of human resources and/or a better use of their knowledge can deliver a considerable contribution to the overall innovativeness of the organization". Thus, public and private actors are likely to cooperate to mobilize complementary resources and competences that are employed to produce these intangible and non-technological innovations, and lead to the sharing of risk related with mobility of human capital or with the short life cycle of service product.

Furthermore, in many public services, the performing of traditional public services needs new an innovative structure (new approaches, solutions, strategies, etc.) to face the rapid changes and complex issues (e.g. health challenges, climate changes, security concerns) that face the public services around the world (Australian Management Advisory Committee, 2010). Either on national or international level, no single public organizations or country can have the skills, enough sources of knowledge and information to address the required innovative structures. Thus, cooperation between public organizations and other national or international public and private service organizations is likely to be an efficient strategy to face internal public service organization deficiencies.

1.4. Public and private role in ServPPINs

In TechPPINs, public actors are mainly providers of complex knowledge and they often consist of universities, and public research centres. In ServPPINs, much more public service providers are involved, for example health, education and transportation sectors. In this respect, public services cooperate with private services to produce innovation in service. Consequently, public actors will provide a wide range of non-technological resources (e.g. skills, competences, knowledge, approaches, procedures and laws).

Private actors in TechPPINs are mainly industrial firms which produce mainly technological goods (artifacts) (electrical machinery, medical goods, motor vehicles, etc.). In ServPPINs, private actors may belong to any type of service sectors, for example, financial intermediation, wholesale and retail trade, computer, social service, hotels and restaurant. Service sectors use mainly non-complex knowledge (skills, organizational competences, solutions, approaches, etc.) in their production of innovation which is mainly a non-technological one. For example, public and private service organizations cooperate to change their structures or improve back office (e.g. administrative and operational competences, e-production software and processing system) and front office processes (like e-service and managing the delivery of their public services like order management, shipping, delivery and returns management).

1.5. Service innovation in ServPPINs

The ServPPINs are a kind of cooperation between public and private actors established to provide innovation in services. Therefore, the specificities of innovation in services, which have been addressed in chapter 1 and chapter 2, have to be taken into account in the analysis of this new innovation network concept.

This can be done by mobilizing the service innovation framework discussed in chapter 2, which distinguishes three different approaches: assimilation, differentiation and integration.

In the assimilation approach, innovation in services is limited to the adoption of technological innovation developed in manufacturing (more rarely internally). Innovation in ServPPINs envisaged from the assimilation approach (see table 1) is limited to its technological dimension. This means that ServPPINs are formed to adopt technological innovations produced in industrial sector or to produce them internally. Therefore, the interactions between network actors have a technological nature, and the process of implementing innovation is planned (predictable) as the framework where innovations are implemented is well-structured in the form of R&D departments or project groups (Djellal and Gallouj, 2010c). In the second part of this chapter, we provide a pattern of conceptual framework for ServPPINs that describes the process of technological innovation along the ServPPINs life cycle.

The demarcation approach represents a shift of the discussion from PPINs focused on technological innovation to PPIN focused on the production and diffusion of non-technological innovation. In such ServPPINs debate (see table 1), the innovation process is structured through less planned and less predictable processes (Toivonen et al. 2007; Toivonen, 2010, Djellal and Gallouj, 2010c).

Table1: ServPPINs by degree of complexity (Djellal and Gallouj, 2010c)

Type of innovation	Origin	Adoption	Production		Adoption/production
	Nature	Technological innovation	Technological innovation	Non-technological innovation	Complex, architectural innovation
Dominant type of innovation process		Planned innovation		Unplanned innovation	Planned/unplanned innovation
Type of ServPPIN		ServPPIN set up to adopt technological innovation	ServPPIN set up to co-produce technological innovation	ServPPIN set up to co-produce non-technological innovation	ServPPIN set up to adopt/produce complex architectural innovation
Theoretical perspective		Assimilation		Demarcation	Integration

Finally, the integrative approach is the most comprehensive perspective for explaining innovation in services. It provides a broad framework that includes both technological and non-technological innovation. More generally, in ServPPINs debate (see table 1), the integrative approach enlarges the perception of innovation activities to encompass different grouping of innovations: service and manufacturing, visible and invisible, technological and non-technological, simple and complex modes of innovation, predictable and unpredictable.

1.6. ServPPINs types

Depending on the different theoretical perspectives and on the following characteristics of innovation: its nature (technological or/and non-technological), its origin (adopted or/and produced), the dominant type of innovation process (planned or/and unplanned), the complexity of innovation (simple or/and complex), one can distinguish four main types of ServPPINs (Djellal and Gallouj, 2010c) (see table 1):

1. ServPPINs for adopting technological innovation. Here, public and private actors cooperate to adopt planned and simple technological innovation developed in manufacturing sector

2. ServPPINs for producing technological innovation. The production of planned and simple technological innovation in services is the main goal for cooperation between public and private actors.

3. ServPPINs for producing non-technological innovation. Here, public and private actors cooperate mainly to produce unplanned and simple non-technological innovation (for example, market innovation, organizational, social and ad-hoc innovation).

4. ServPPINs for producing architectural innovation. It is considered the more complex type of ServPPINs (Djellal and Gallouj, 2010c), because of the multiple modes of innovation it may encompass, and the managerial problems it may pose that are related to the interaction between these diverse modes of innovation.

2. Conceptual framework for ServPPINs

The ServPPINs framework has the same main constituent elements than the TechPPINs, but with major differences in the public and private actors involved, their cognitive resources mobilized and the measures of SNA. These differences rise because of the service nature of innovation output.

The network life cycle model which was successfully applied to TechPPINs is expected to be consistent with all types of ServPPINs. This was confirmed in ServPPINs project (ServPPIN project, European Commission) where it was found that the 12 case studies of ServPPINs in transport sector and 11 out of 16 cases in knowledge-intensive services support the life cycle model hypothesis. As we have mentioned previously, the network life cycle model consists of three main phases: crystallization stage, commercialization and entrepreneurial stage, and consolidation and firm growth stage. Each stage is characterized by some specificities in the nature of the actors involved and the degree of involvement of each actors (the enabling role or control power), the size and type of cognitive resources mobilized.

Like TechPPINs, the ServPPINs conceptual framework works as a binding mechanism (coordination mechanism), which provides coherence between the public-private "socio-cognitive" interactions along the network life cycle growth model to produce successful innovation output (technological and/or non-technological) in service sector.

The coordination mechanism is divided into two important processes. The first is similar to the innovation mechanism (process) in the TechPPINs conceptual framework developed in chapter 3. Thus, the public and private service organizations cooperate in a dynamic and social process through the network life cycle model to produce service innovation. In other words, the first process represents the synthesis between the major four constituent elements (heterogeneous actors (public and private), dynamic interaction process, and SNA analysis and network life cycle model) of the conceptual framework to produce service innovation.

The second is described as "adaptation mechanism" for the conceptual framework, which considers the differences in the ServPPINs and their associated innovation output. Thus, the conceptual framework is likely to have different innovation mechanism for each ServPPINs type i.e. the synthesis process between the four structural elements of the conceptual framework is different in each ServPPINs type. For example, the interaction process between public and private actors along the life cycle model and the cognitive resources mobilized in "ServPPINs set up for technology production" are expected to be different from that for production of service-based innovation.

Here, the combination of the product life cycle model and the SNA is used for describing the innovation mechanism (the dynamic process of interactions between network actors) under the conceptual framework. It will allow us to incorporate three important elements: (1) the social aspects of interaction (2) the heterogeneous public and private actors (3) and the characteristics of innovation in services. In other words, by using the SNA measures, we expect that the adoption of the three-stage life cycle model for ServPPINs will reveal how the social interaction processes between public and private actors change over time to develop successfully a service innovation output, the role of actors in the innovation processes and the nature of innovation output.

2.1. The innovation mechanism in "technology-adoption ServPPINs"

The cooperation between public and private service sectors to adopt technological innovation is likely to be well-justified in the assimilation perspective for innovation in services. Some service sectors (e.g. personal services which include hotels and restaurants, domestic services and repair) in their innovation activities still depend on the adaptation of technology from the manufacturing sector (supplier dominated firm).

Despite the technological nature of innovation output, it is expected to find major differences between the corresponding innovation processes and that in TechPPINs, mainly in the nature and role of actors. Actors here are simple consumers of technology developed elsewhere (Djellal and Gallouj, 2010c), and their role is often simply to organise joint use of the technology. Therefore, complex technological interactions between network actors are not the objective of such a network. The gathering of information about the characteristics of the adopted technologies, strong internal administrative and management system with clear specification of tasks for using and adopting the technology are expected to be the main contributions of public and private actors in this case. Thus, universities and public R&D institutions are not the major public participants. The participants are rather public actors who are generally non-complex knowledge producers such as public administrations, health and transportation sectors.

Our goal now is to combine the product life cycle model and the SNA to describe the dynamics of interaction processes in "technology-adoption ServPPINs".

The design or crystallization stage begins with the need of a group of public and private organisations to apply a new technological device developed elsewhere. The inability of developing this technology internally drives them to interact in order to know their preferences and competences, exchange opinion and information regarding the technology in question. After the adoption of the technology, the network actors employ it to produce a new service output. Social networks are important in this case to form a platform of information exchange which leads to better perception of the benefit and risks of adopting the innovation (Hartwich and Scheidegger, 2010). According to the actor-related and network related measures, it is expected that neither the public nor the private actors will have high central role (control power) in the innovation process while the other has a peripheral role i.e. the power and influence are likely to be distributed between them. This may be associated with the function of ServPPINs which is limited to the adoption of a technology developed elsewhere, and with the simple role of network actors which are mainly focused on the joint use of the technology. Because of the power distribution between public and private actors, the network is expected to be a stable one with high social capital and fast diffusion of knowledge and technology (Pyka et al. 2010).

Related to the network life cycle model (see table1 in chapter 3), the commercialization stage is characterized by the growing role of private actors where new private firms (often start-ups) enter the network, the large participation of public actors, the first articulation of demand and large adjustment gap between potential demand and instant demand. Therefore, there are re-distributions of centrality power between network actors in the way the private actors' role will increase and public actors still keep a significant participation. The interactions (connections) are re-arranged to have a more connectivity with the new private actors to respond to the high demand of knowledge and information and to facilitate their access to the adopted technology. But this is expected to lead to the reduction in the overall density and connectivity.

Finally, the consolidation (implementation) stage (see table 1 of chapter 3) is characterized by the declining participation of public actors and well articulated demand generating. Thus, the role of private actors increases compared with the role of public actors and a shift in the control power from public to private actors is expected. Private actors cooperate intensively with each other (high connectivity) to have a maximum access to the new adopted technologies and maximum learning process. The nature of knowledge distributed is still concerned with the characteristics of new adopted technologies and the efficient strategies for joint use.

2.2. The innovation mechanism in "technology-production ServPPINs"

In this mode, public and private actors cooperate to produce a visible and planned technological innovation. The mobilizing of complementary complex knowledge and technological resources are the core of cooperation and a pre-condition for a successful technological innovation output along the network life-cycle.

Despite the technological nature of innovation, it is expected that the innovation processes in this conceptual framework will be different from those in the "technology-adoption ServPPINs". This is related to the nature of network actors and knowledge exchanged which are likely to be similar to those in TechPPINs.Complex knowledge and information from universities, research centers and R&D institutions are crucial for the success of innovation in such networks. Accordingly, the traditional public actors (universities and research centers) will be key participants and will have a more control role in the innovation process. In some kinds of networks, local or national institutions play prominent role in the initiation of new collaboration relationship like in many innovation clusters. This is not canceling the role of private providers of complex knowledge (laboratories and research centers). Thus, we are talking about complex interactions where complex knowledge and technology are mainly exchanged.

To analyze these ServPPINs, we combine once again a product life cycle analysis and a SNA. Science-driven actors (government and research centers) and demand-driven actors (public system operators) are the main participants in this case (see table 1 in chapter 3). Public researchers from universities, research centers (public and private) collaborate to study a new idea or scientific phenomenon to produce new technology. Then the basic knowledge or sciences will be linked with functional technology.

It is clear from the technological nature of this network that the public actors embodied in universities and public research centres and R&D institutions have a high control power or a high degree of centrality in the production and diffusion of knowledge in the network and the initiation of new innovation processes in the first stage. Other non-technical public and private service organisations are likely to be connected to each other through those high technological public actors. The density and degree connectivity of network is supposed to be low (Pyka et al., 2010), and the stability control and flow of knowledge along with technologies in the network depend on the public providers of complex technologies.

In the commercialization stage, high potentials of technology and the first articulation of demand attract entrepreneurs (private service firms, public services and start up companies) to contribute for the development of the technology. The role of private organizations increases (compared with the crystallization stage) to face the demand expected for the new technology. This requires new channels and fast diffusion of information and knowledge throughout the whole network. Thus, a high network density and connectivity is expected, while the degree of centralization of network is mitigated by the re-distribution of power toward more private actors' role, which will result in high interactions between private and public actors in this case as well as the production of more social capital in the network.

Finally, in the consolidation or firm growth stage, new technologies become commercially competitive, and new technologies displace sitting technology. More and more service private actors enter the network, while public actors' role decreases. Centrality degree is re-distributed towards a more centrality or control power for the private firms which gain more strategic position to control the production of technological innovation. Connectivity between private firms will increase which might lead to the constitution of cliques[8] or cohesive subgroups of private service firms to facilitate the exchange of knowledge and technological resources.

2.3. The innovation mechanism in "non-technology production ServPPINs"

In such networks, public and private actors cooperate to produce intangible and non-technological innovation (e.g. organizational changes, marketing innovation, ad-hoc solutions and social innovation). Network participants will include heterogeneous private and public service organizations (private service firms, local or national public administrations, public organizations as hospitals and transports, semi-public firms like charities, non-government organizations (NGOs) and also non-profitable businesses).

Thus, the diverse and large number of actors might lead to complex and intensive interaction processes with a large and heterogeneous amount of exchanged tacit knowledge and information. Social network is vital to enable the formation of platforms for mobilizing non-complex knowledge and information and joint learning processes.

Using life cycle model combined with SNA is also useful here to reveal the dynamic interaction processes which lead to non-technological innovation in services.

[8] Clique consists of homogeneous group of actors who are more connected to each other than any other partners of network.

The public actors' degree of involvement in the crystallization stage is expected to be different from that in the technological ServPPINs. University and public research centres lose their dominant role as major provider of knowledge. Public non-technology-intensive service organisations and semi-public organisation or non-profitable organisations (e.g. trade unions) are likely to play the central role (control power) in this stage.

In the commercialization stage, the network attracts new actors (mainly private services) who would like to invest and bridge the gap between potential and instant demand for innovative products. Re-arrangement for interaction processes happens to face the seek-out of newcomers for knowledge, information and skills. More channels and more intensive interactions between public and private actors are available for the exchange of knowledge and information between network and newcomers. The enabling power is also distributed between public and private actors who therefore have a significant effect on the innovation process. High connectivity and density are expected because of the high expected interactions between public and private actors.

In the consolidation stage, demand is well articulated, the role of public actors diminishes and the private actors are expected to be dominant in this stage. Network actors are mainly seeking for stability and an efficient production of new service innovation. Therefore, high speed diffusion and lower cost in exchanging knowledge and information are particularly important in this case. The nature of interactions and knowledge exchanged are different from the first and second stage as far as it is not the intensity of interactions which is vital for the efficiency of innovation production but the quality of interactions and the speed of information flow. Private actors are expected to have a crucial role in the achievement of such innovation production efficiency through the high control power they have on the flow of knowledge, skills and competences.

The physical interaction between network actors (service providers and clients) is crucial for some types of innovation in services (for example, in the field of consultancy and knowledge intensive services). This is related with the co-production specificity of many non-technology-intensive innovations in services, which requires a direct and intensive interaction between service provider and clients. For example, the direct interaction between patients and doctor in the diagnosis of disease and their responses is important for successful and efficient treatments. Therefore, the success of interaction processes requires a high amount of social capital, mainly informal social capital (like, trust, mutual understanding and friendship).

The role of clients in the innovation process is not fixed. It changes depending on the ability of network actors to take advantage of consumers' competences (absorptive capacity of network actors), and on the stage of the network life-cycle path. For example, the role of consumer in the crystallization stage is different from his role in the commercialization stage. Martin et al (1999) determined four main roles for consumers in service provision: specification of the service, pure co-production, quality control, and marketing. The change of clients' role leads to change in the amount of associated social capital.

2.4. The innovation mechanism for "complex or architectural innovation" ServPPINs

The innovation mechanism for the three ServPPINs types discussed before is likely to be present in the architectural ServPPINs. The production of innovation in architectural ServPPINs is a result of complex and non-complex processes of interactions between diverse actors with heterogeneous competences and objectives. Actors extend from public and private organizations for producing complex knowledge (like, universities, public and private research centers and R&D institutions) to private and public non-complex knowledge, skills and competences (like, health care establishments, public and private hospitals, consultants firms, knowledge intensive business services, semi-public institutions and public administrations). These knowledge, technologies, skills and competences are employed to adopt or/and produce both technological (e.g. product and process innovation) and non-technological innovation (e.g. marketing and organizational innovation, procedures, approaches and ad-hoc innovation).

The overlapping between different types of innovation output may add some complexity on the determination of the dynamics of interaction processes, actors' role and the SNA measurements. High intensive and heterogeneous interactions are likely to be presented simultaneously between network actors, and the combination between them in one framework and the mobilization of complementary cognitive resources are important for the production of innovation.

Each stage of the network life cycle has its own requirements of cognitive resources (technological and non-technological) that can be met with a judicious selection of network actors (public and private) and consistent interaction processes. In other words, in each stage of the network life cycle, the interactions should be able to facilitate mutual understanding, exchange of knowledge and technologies between network actors, learning process, and management of any inconsistency (conflict) between network actors.

We also combine here a product life cycle model with SNA. In the initial stage, a high number of actors (e.g. service firms, public labs and research centers, and public administrations from public services) interact between each other to mobilize their cognitive opportunities which lead to the expansion of their own technological and non-technological knowledge. This initial stage is expected to take a long time and the number of participants might also change.

Due to the complexity of innovation, the public actors represented by labs, research centers and some public administrations are expected to have more enabling power in the initiation of such networks. Thus, they have the ability to control the flow of knowledge and information between the different actors, and therefore have important role in the innovation process. Private Service firms are present in this case but they have less enabling power.

A large amount of social capital is expected compared to the initial phase in the previous three ServPPINs discussed. This is related to the long and complex process of initiation stage which may include several steps (e.g. problem or opportunity description, negotiation, deliberation and launching of the network). Because of the high degree centrality of the public actors, most connections and interactions between the network's actors should pass through them, thus high density and connectivity may not be present.

In the commercialization phase, similarly to the ServPPINs case discussed previously, new actors are attracted by the network under the high demand of consumers for innovation outputs. The newcomers to the network are mainly private service firms which seek for profit or public service institutions who seek to provide public services and increase the welfare of consumers. Thus, there is more distribution of power from public actors to the private ones. The public actors open new interactions with newcomers, who will exchange their competences (technological and non-technological) with the present actors. Network density and connectivity are important in this case for a quick distribution of knowledge and information. Short distance and high clustering coefficient are also important for the exchanging of increasing demand for complex knowledge. Therefore, high amount of social capital (formal and informal) is expected to be found in the network, but its distribution is less heterogeneous between public and private.

In the third phase, intensive interactions and considerable knowledge flow are expected, and knowledge generation in networks reaches its maximum point (Pyka et al. 2010). The higher degree of centrality and large amount of social capital are expected for the private actors. This is important to mobilize the non-technological competences of service firms (knowledge and skills, organizational competences...etc.) to produce the non-technological innovation. High connectivity between private actors is important to exchange their cognitive resources, and high network density is important for the stability of the network and for the production of innovation (rapid flow of information with minimum cost).

The diversity of knowledge and technologies that might be produced in this stage of the life cycle, might lead to the creation of cohesive subgroups. Each clique is likely to be more efficient than any other part of the network in producing one or more modes of service innovations (technological and non-technological) (Pyka et al. 2010). For example, in architectural innovation in hospital, it is expected to find a clique of actors that is specialized in producing bio-pharmacological innovation (new medicines and new pharmaceutical substances), a clique producing hard medical innovation (system for providing health care, diagnostic equipment), and another producing intangible medical innovation (protocols, diagnostic strategies) (Djellal and Gallouj, 2005).

Conclusion

This chapter sought to go beyond the TechPPIN perspective, focused on technological innovation and manufacturing sector. Thus, it highlighted the concept of innovation networks in the service sector, in which public and private service organizations cooperate to provide new innovation in services (ServPPINs). Therefore, we have extended the conceptual framework designed for TechPPINs in chapter 3 in order to account for the services and innovation in services emerging from the cooperation between public and private actors in a dynamic, social network structure. On the basis of Djellal and Gallouj (2010) taxonomy of ServPPINs, we have provided parallel taxonomy of ServPPINs conceptual framework. Each type of conceptual framework is designed to describe the innovation process (mechanism) in one type of ServPPINs, and the innovation process in each one is based on: the nature of public and private participants and their associated cognitive resources, and the value of SNA (actor and network related measures) in each stage of network life cycle.

Conclusion of Part 2

In part 2, we provided a theoretical discussion about the INs as an important strategy for the promotion of innovation in the service sectors. We found that INs were highly focused in the manufacturing sector in the last 20 years, motivated by the high employment of complex knowledge (mainly R&D) in innovation, while in services they were rarely discussed. Thus we expanded the discussion of traditional INs to include INs in service sectors mainly networks that involve the cooperation between public and private service organizations (ServPPINs). The conceptual framework developed in chapter three for the TechPPINs was adapted to be applied to ServPPINs. On the basis of Djellal and Gallouj's (2010c) ServPPINs taxonomy, a parallel taxonomy was developed which consists of four modes of the ServPPINs conceptual framework. Each mode is characterized by the nature of public and private actors, the SNA in each network life cycle and the nature of service innovation produced.

In the next part of this work, we will try to provide empirical results to support the theoretical analysis. Two empirical works will be provided. The first is a discussion for of a real ServPPINs (Lyonbiopole). We will show how the innovation outputs are produced along with the network life cycle. The role of public and private actors, the SNA measure and the network structure will be clearly illustrated using graph theory. The second will provide an estimation of the effect of cooperation for innovation (ServPPINs) on the innovation output in services.

Part 3: Innovation mechanism in real ServPPINs and the cooperation for innovation strategy in French service sector

Introduction

In this part, we provide two empirical illustrations of ServPPINs. The first one is an application of the ServPPINs conceptual framework to "Lyonbiopole" innovation clusters where public and private organizations cooperate and mobilize complement cognitive resources to produce complex innovation output in health sector. The second one (chapter 6) is an empirical application of the role of cooperation for innovation in services using data from the fourth community innovation survey, in the case of France.

The conceptual framework developed in chapter 4 for an architectural innovation in ServPPINs is employed in chapter 5 to discuss the dynamic growth of social interactions between public and private actors along real network life-cycle growth model, to produce complex innovation (technological and non-technological innovation). In other words, chapter 5 provides a real description of how the product life cycle model functions in real ServPPINs, where the process of interactions between heterogeneous public and private actors, type of cognitive resources exchanged and the nature of service innovation produced are well defined.

In chapter 6, we finally examine and evaluate explicitly the effect of size of public-private cooperation on the development of innovation in service sectors. This chapter is based on data from the French fourth community innovation survey (CIS4). This application is essential to provide evidence of the positive relationships between PPINs and of innovation in service sectors. It also provides three important comparisons: The first between cooperation for innovation strategy (PPINs) in service and manufacturing sectors. This is important to reveal the relative importance of PPINs in services compared with manufacturing sectors. The second provide comparison between public-private INs and private-private INs to show the relative importance of having heterogeneous actors to provide more efficient innovation output in services. In the third, we compare the effect of cooperation for innovation on different types of innovation (product, process, marketing and organizational innovation).

Chapter 5: The Lyonbiopole Public-Private Innovation Network: Formation and Dynamics

Introduction

The emergence of non-linear or cooperative innovation in the last 30 years has led to the development of diverse patterns of non-linear modes of innovation processes like innovation systems, innovation networks (INs) and innovation clusters (Freeman 1987; Lundvall 1992; Grabher 1993; Camagni 1991; Edquist 1997; Manley 2002; Eickelpasch et al. 2002; Bross and Zenker, 1998; Gilbert et al., 2010; Ahrweiler et al. 2003). These patterns are designed mainly to be applied to innovation in manufacturing sector (Silicon Valley in a prominent example), in which different actors cooperate to produce new technological innovation. This was consistent with the traditional view of the manufacturing sector as the main generator of productivity in economics.

Recently, due to the increasing focus on services as highly innovative and productive sectors, many INs have been established in services (e.g. INs in health sector, knowledge intensive business services, tourism). The connectivity (interaction) between public and private actors in such service INs (public-private innovation networks in services "ServPPINs") is essential to mobilize complementary resources from several public and private service sectors to provide innovation in services (see Djellal and Gallouj, 2010c).

On the basis of different variables characterizing innovation in services; nature (technological or/and non-technological), origin (adopted or/and produced), dominant type (planned or/and unplanned) and complexity (simple or/and complex), Djellal and Gallouj (2010c) classify the ServPPINs into four main types. 1) Simple ServPPINs for adopting technological innovation. 2) Simple ServPPINs for producing technological innovation. 3) Simple ServPPINs for producing non-technological innovation. 4) Complex ServPPINs for producing architectural innovation.

In chapter 4, we have produced a theoretical framework (combining SNA and network life cycle growth model) to address ServPPINs. Here, using a concrete case (Lyonbiopole competitive cluster), we want to test how the collaboration between public and private actors in ServPPINs leads to the production of new service innovations. It is not possible with the available data for Lyonbiopole to determine the amount and type of innovation produced. The data only enables us to know the mechanism of innovation i.e. how the interaction (collaboration) between public and private actors enables them to mobilize the cognitive resources which are used to produce innovation.

The innovation process in Lyonbiopole as “a health care shield” might be explained by the combinatory or architectural approach (principle) (Djellal and Gallouj, 2005). Thus, Lyonbiopole is considered a complex system of other constituent services where different types of technologies are employed. Innovations outputs are architectural (complex) including both technological (tangible medical innovations like interactome, micro-nano technology, protein expression, optimizing system-molecule, vectorology, vaccinomics or ex vivo screening, cell biology and culture media, structural biology)[9] and non-technological innovations (like, diagnosis service, therapeutic strategies prevention programs, training activities, delivery system and new administrative competences). Thus, the conceptual framework of thecomplex or architectural ServPPINs developed in chapter 4 is applied here to discuss the dynamics of social interactions between public and private actors along network life-cycle

[9] http://www.lyon-bio-pole.fr/innovate/Lyonbiopoles-thematics.html

growth model in order to produce new innovations. For this purpose, graph theory and SNA analysis combined with life cycle theory will be used.

Our work is organized as follows. In the first part, we will discuss Lyonbiopole history and formation mode (planned or spontaneous). We will employ a mixed strategy of graph theory and SNA combined with life cycle theory to develop “Lyonbiopole” as a case study of public-private INs. We will use secondary sources to figure out the formation and structural features of the network. In the second part, we will discuss the development of Lyonbiopole through the life cycle growth model. This part will discuss some of the factors that were important for the success of the innovation output. These include the nature of cooperation partners, the role of international cooperation, and the structure of Lyonbiopole (small-world network structure).

1. The formation of Lyonbiopole

Competitive cluster is a joint theme-based initiative[10] between different actors (research centers, educational institutions, firms, public institutions, etc) in a given geographic area and most likely formed around sources of knowledge. Knowledge in these clusters is developed, shared and exchanged based on a sophisticated infrastructure, supported by highly concentrated and effective links between entrepreneurs, investors and researchers. In general, the competitive clusters are vital in mobilizing the resources which are important for innovation through the accumulation and localization of technical skill, venture capital, specialized suppliers, services, infrastructure, and spillovers of knowledge associated with the proximity to universities. Lyonbiopole is an example of competitive (innovation) clusters. It is applied here as an illustration for innovation in ServPPINs.

1.1. Lyonbiopole history and objectives

Lyonbiopole was designated as "global competitive cluster" by the French Government in July, 2005.It was founded by 6 main members: BD France,

[10] http://www.safetrans-de.org

bioMérieux, CEA, the Mérieux Foundation, Merial, and Sanofi Pasteur. It includes ten current board members including world's premier firms such as Sanofi Pasteur, Biomerieux, Merial, BD, high potential SMEs (Alize pharm, PX'Therapeutics) and centers of excellence (CEA, Inserm, Lyon University and the Merieux Foundation. Lyonbiopole partners obtain fund from the state, local authorities, Oseo and the European Community (Lyonbiopole, 2008).

Lyonbiopole is considered as a "centre of excellence"[11] in the fields of vaccines and diagnostics and was created as a "healthcare shield" to coordinate a comprehensive approach of human and animal infectious diseases covering diagnosis, prevention, treatment and innovative administration systems. It is built on "the distinctive know-how of Lyon and Grenoble in the Rhone-Alpes region, an alliance between industry biology, structural biology and micro and nanotechnology" (Lyonbiopole, 2010). It combines the expertise of Lyon in vaccine and diagnostic expertise in Grenoble micro/nanotechnologies and in structural biology so as to achieve technological bricks, which will form the basis of production and distribution of new technological and non-technological services that represent the main elements of the "healthcare shield".

Lyonbiopole encourages joint R&D projects and helps them to obtain the best funding. It is considered a "factory" for producing multi-partner R&D projects, and bringing research centers, educational systems with public and private organizations[12]. Thus, it represents an INs where both public and private with corresponding cognitive resources are placed to generate and diffuse cognitive resources which are employed to produce innovation.

1.2. Lyonbiopole Initiator

The first impulse for the initiation of Lyonbiopole came from public institutions. More precisely, it comes from the French government that initiated Lyonbiopole as one of the French "global innovation cluster" and as a new public policy in healthcare system,

[11] http://www.lyonbiopole.com
[12] http://www.lyonbiopole.com

which mobilizes the key factors of competitiveness for different public and private organizations to produce new innovation output in health sector. It is not surprising that Lyonbiopole is initiated by the public sector as far as the health system is still provided by the public sector in most countries.

In a second step, the government has contacted potential members (founders) and informed them about the existing threat or opportunity (e.g. competition with global economics and innovation capabilities). Without the intervention of government, thefounders (BD France, bioMérieux, CEA, the Mérieux Foundation, Merial, and Sanofi Pasteur) may be unaware of the potential opportunity of providing innovative health services (diagnosis, prevention and treatment). Then, the founders build collaborative research (mainly R&D) projects, financed by private finance and/or public support (from the unique inter-fund (FUI), government or local authorities, EU…). Each project mobilizes several actors. All participants in the different projects interact between each other, exchange skills and competences (e.g. knowledge, know-how, technologies), forming an IN (see figure 1) in the healthcare sector.

1.3. Lyonbiopole Formation

Lyonbiopole innovation network was formed by bringing together the actors of different joint projects in one network. In other words, each project consists of several actors connected directly to each other, some of these actors are also common between more than one project, thus they form together an innovation network. Through the connections (interactions) between network actors, cognitive resources will be exchanged (e.g. knowledge, technologies and know-how). For example in 2005 three projects (GAP, PRAVIC and BIOTHERABIC) were financed by public funds. GAP aims to find a solution to avian and pandemic influenzas, it includes the following actors: Merial (project leader), sanofipasteur, bioMérieux, P4 laboratory, CNR for influenza viruses (HCL) and the InteractomeLaboratory (INSERM U503 / IFR Biosciences). PRAVIC aims to develop new bio-molecules for rare infectious pathologies, it includesOPi (project leader), Protéin'eXpert, HCL, CLB, Vaccinex.

BIOTHERAPIC aims to find herapeutic solutions to Hepatitis C, it includes Transgene (project leader), Epixis, HCL, CHU Grenoble, Inserm, CNRS. These three projects through the common actors between thenm form an innovation network (see table 1). The innovation network in Table 1 will be represented using a graph theory [13](Albert and Barbasi, 2002; Cowan, 2004, Pyka et al. 2010). The graph is designed using a social network analysis program "UCINET" which shows how the network actors are connected through direct and indirect ties. For example, figure 1 shows the network structure in 2005 using the whole data from all joint projects in that year.

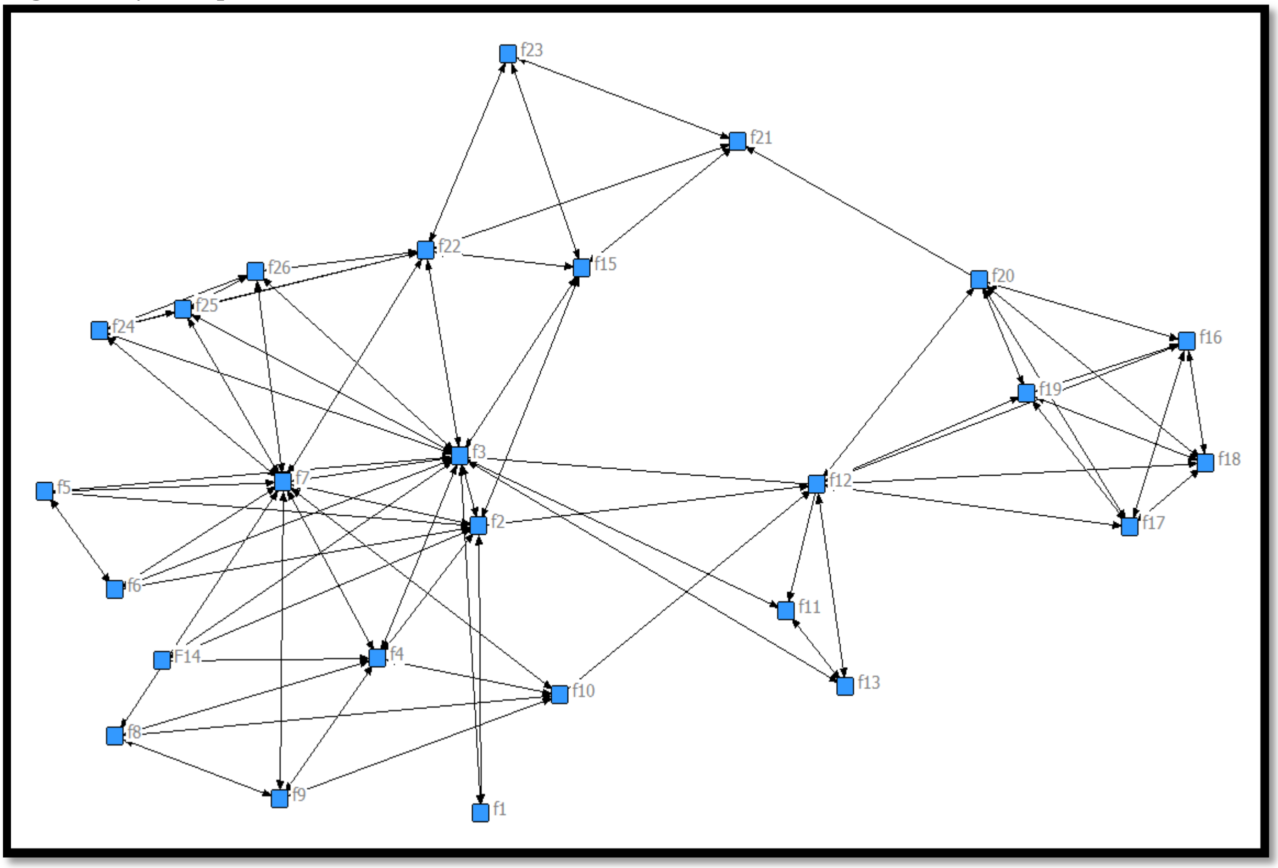
Table 1: innovation network between the actors of three projects (GAP, PRAVIC and BIOTHERABIC)

	Merial	Sanofi pasteur	BioMérieux	P4 laboratory	HCL	INSERM	OPi	Protéin eXpert	CLB	Vacci-nex	Trans-egene	Epixis	CHU Greno-ble	CNRS
Merial	0	1	1	1	1	1	0	0	0	0	0	0	0	0
Sanofi Pasteur	1	0	1	1	1	1	0	0	0	0	0	0	0	0
BioMérieux	1	1	0	1	1	1	0	0	0	0	0	0	0	0
P4 laboratory	1	1	1	0	1	1	0	0	0	0	0	0	0	0
HCL	1	1	1	1	0	1	1	1	1	1	1	1	1	1
INSERM	1	1	1	1	1	0	0	1	0	1	1	1	1	1
OPi	0	0	0	0	1	0	0	1	1	1	0	0	0	0
Protéin eXpert	0	0	0	0	1	0	1	0	1	1	0	0	0	0
CLB	0	0	0	0	1	0	1	1	0	1	0	0	0	0
Vaccinex	0	0	0	0	1	0	1	1	1	0	0	0	0	0
Transegen	0	0	0	0	1	1	0	0	0	0	0	1	0	1
Epixis	0	0	0	0	1	1	0	0	0	0	1	0	0	1
CHU Grenoble	0	0	0	0	1	1	0	0	0	0	1	1	0	1
CNRS	0	0	0	0	1	1	0	0	0	0	1	1	1	0

1 : the actor in the column cooperate (exchanges cognitive resources) with that in the row
0 : no cooperation between the actor in the column and that in the row

[13] In graph theory, networks represented as graphs denoted G (V,E), where V refers to a set of vertices, nodes, points, or actors, and E refers to a set of edges, lines, links, ties, or relationships (Borgatti and Everett, 1992).

Figure1: Lyonbiopole Innovation Network in 2005



1.3.1. Social Network Analysis

Social Network Analysis (SNA) is an approach that describes the flow of cognitive resources (information, knowledge, skills, technology, etc.) between a group of actors (e.g. individuals, organizations, and public administrations). SNA gives insights about the role of actors in the production and diffusion of resources between network actors and the composition, structure and dynamic of the network. The SNA depends on three main points; the actors, relations (e.g. exchange of resources, problem solving, communication between actors, friendship, and kinship relations) and the resources exchanged. In the past, the SNA has been used in the study of "kinship structure, social mobility, science citations, contacts among members of deviant groups, corporate power, international trade exploitation, class structure, and many other areas"(Scott, 1988), and recently in IT networks, computer networks, and INs.

In the discussion of innovation processes in Lyonbiopole, quantitative measures from social Network Analysis (SNA) are obtained through the graph theory (mixed strategy of SNA and graph theory). These measures couldn't lead to a specific estimation for the influence of social capital on innovation output in Lyonbiopole, but they illustrate the structure of interaction processes, channels of information flow and the position of different actors in the network. Consequently, the external structure of network reveals the relative role of network actors in the innovation processes.

The SNA analysis consists of two levels; tie-level (or ego-network) and a whole network analysis (Haythornthwaite, 1996). In the tie-level analysis (ego-network analysis), the focus is on one actor (ego-actor) and his relation with the rest of network actors, and the whole network is analyzed from his perspective (Haythornthwaite, 1996; Pyka et al.2010). The tie-level shows with whom a typical actor exchanges different kinds of information. Actor-related measures are the most frequent SNA which are employed to measure the key role of the ego-actor and other network actors. The whole-network analysis is a measure of cohesiveness of the network (attributes of the whole network). The focus here is on the relationships, interactions and structure of the whole network. At this level of analysis, the network-related measures will be employed to reveal the changes in the whole network structures.

a. Actor-related measures

Actor-related measures can distinguish between the different roles of network actors who are expected to have different roles in the network. They provide us with information about the control degree of the resources flow by each actor in the network and about which actor is well positioned in the network. In the innovation network, actor-related measures can give us important information about the effect of each actor on the innovation process through its effect on the flow of cognitive resources through the network.

Centrality is one of the most important actor-related measures. It is an expression which measures how tightly the network is organized around its most central actor (Freeman, 1979; Scott, 2000). Under this assumption, more central actors in the network will be able to access the highest amount of information distributed in the network more quickly than other network actors with more controlling power in the diffusion of cognitive resources. There are a lot of centrality measures. In this study, we will use three of them: Degree, closeness, and betweenness. Degree centrality represents the incoming and outgoing direct ties which an actor has with his direct neighbors (actor with high degree centrality can access larger amount of information than those with lesser degree of centrality). Closeness centrality represents all direct and indirect ties to all other actors in the network (actor with high closeness centrality means a short path to other network actors compared to less closeness centrality actors). Betweenness centrality gives insight about the control of information flow in the network (actor with high betweenness centrality have more central role compared to other network actors. It also measures how much the actor serves as bridge between other network actors (Haythornthwaite, 1996; Pyka et al. 2010).

b. Network-related measures

Network-related measures include several indicators that can measure the cohesiveness, the presence of high socializing relationships between network actors, and to what level the network actors can access the same information and knowledge (Haythornthwaite, 1996). Herein, we will define some of these measures that we will utilize the analysis of the dynamic growth of Lyonbiopole.

1. Density

Density of a network describes the degree of connection of the network actors with each other. In other words, it is the ratio of the number of actual ties between network actors to the number of all potential ties in the network. In a high density network, actors are more connected to each other than in a low-density network. In innovation networks, high density is important for a stable network and for high flow channels and high speed of cognitive resources flow.

2. Clusters or cliques

They are subgroups of actors who are highly or fully connected to each other when compared to other network actors. In cliques, the actors can reach each other directly in one step without intermediary (Haythornthwaite, 1996). Cognitive resources are distributed easily and quickly between actors in clique.

3. Connectivity

Connectivity of a network is defined as the number of nodes that must be removed in order to leave the network unconnected. Higher connectivity between two actors means that there are many channels for information flow between them. Connectivity guarantees network actors a fast access to a large amount of cognitive resources in the network beyond the knowledge and technologies that direct partners can provide. "The larger the connectivity of a network is, the less vulnerable the graph becomes disconnected" (Wasserman and Faust, 1994).

4. Degree distribution

It provides information about the homogeneity and heterogeneity of actors through measuring the variance of degrees within the whole network (Pyka et al.2010). High degree distribution in the network indicates that some actors have more positional advantage related to other network actors, or some actors have more power than other network actors.

5. (Mean Geodesic) Distance

Geodesic distance between two actors represents the shortest number of edges between them. While the mean geodesic distance represents the average geodesic distance for the whole network actors. Small mean geodesic distance means that the cognitive resources will flow more quickly and efficiently between the network actors.

1.3.2. Lyonbiopole formation mode (spontaneous or planned network)

There are mainly two modes of network formation: Spontaneous network (bottom-up network) which spontaneously emerges and planned network (top-down network) which is created by one or a small group of actors. The environmental pressures or threats (competition from external actors, common economical or non-economical problem) and the perception of a shared interest by the relevant actors and their willingness to cooperate are necessary conditions for spontaneous formation of a network (Pyka et al.2010). Spontaneous network starts as informal, and entrepreneurs play the vital role to make the network function and develop the innovation in its initial shape. The planned network is popular when shared interest and the necessity to cooperate is not well appear for individual actors (Pyka et al.2010). Therefore, a planned or enabled actor (like individual, firm and public institution) is needed to contact other actors and inform them about the environmental pressures or economic opportunity that promotes cooperation. Planned network tends to have many professional elements in place, but lacks informality and trust to facilitate learning process and exchange of cognitive resources, which could be achieved through the emergence of an open and collaborative culture to facilitate collaboration and integration of activities. The determination of the formation mode in most of the networks is crucial to verify the evolution, composition and structure of the network at later stage of their life cycle.

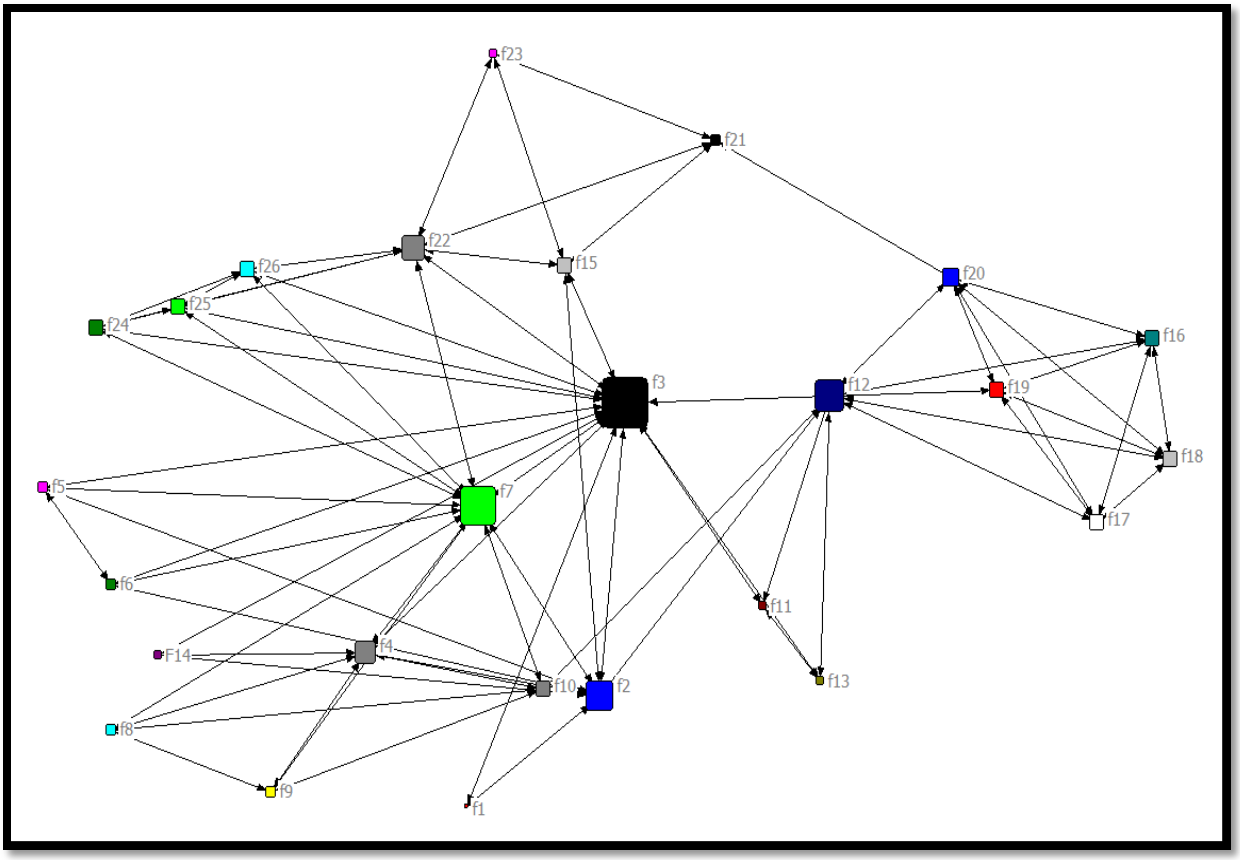
In the case of Lyonbiopole, in the formation year (2005) the founders[14] (BD France, bioMérieux, CEA, the Mérieux Foundation, Merial, and Sanofi Pasteur) called for R&D projects (e.g. GAP, PRAVIC, BIOTHERAPIC…). The actors of these projects and their interactions are the main elements in the network structure (see figure 2). Network actors are heterogeneous and involved in different economic activities: Scientific and academic organizations (e.g. CNRS, Inserm, and Lyon1 University), hospitals (e.g. HCL), SMEs (Transgene, Protein'eXpert) and large companies (e.g.

[14] The founding actors are among the network actors, but not necessarily the central ones.

Merial, BD, Sanofi Pasteur). The question is how the interaction between these actors determines the formation mode of Lyonbiopole?

Using a mixed strategy of graph theory and SNA, we observe a relatively high unequal degree of distribution as regards the degree centrality measure, with 5.61 mean values, variance of 8.62 and high difference (13) between maximum degree (15) and minimum degree (2), which indicates a presence of heterogeneity (4.90% degree of heterogeneity) between network actors. It means that not all actors maintain a similar number of relationships, and not all of them are homogeneous in their power and influence inside the networks. Consequently, some actors have higher roles in the process of innovation through their central position and control on the flow of cognitive resources. The network centralization is 40.67%, which means that there is no central actor who can control alone the flow of information and control the power inside the network. The network is controlled by more than one actor or a group of enabling actors. The Public scientific and academic organizations (center of excellence) f3 (CNRS), f7 (Inserm), and f12 (BioMerieux) are the network's enabling actors, with degree of centrality 15, 12 and 10 respectively (see figure 2). The high degree of centrality (large number of ties) increases the probability of acquiring and diffusing cognitive resources. Both closeness and betweenness centralities measures denote a result similar to degree centrality (see table 1).

Figure 2: Degree centrality for Lyonbiopole in 2005



The high variance and heterogeneity do not match with the spontaneous network characteristics, where most actors know each other and maintain a similar number of relationships. These characteristics match with a planned network that is characterized by the unequal degree of distribution. The relatively low value of network centralization (40.67%) that seems to contradict this result[15] can be explained by the fact that Lyonbiopole has no one single enabling actor. The power and influence are distributed between a group of enabling actors (CNRS, Inserm, Lyon1 university, BioMerieux) (see figure 2). Having a group of enabling actors in Lyonbiopole is consistent with the fact that high technological and non-technological competencies are required to achieve the “Healthcare Shield” in Lyonbiopole, which cannot be controlled by one enabling actor. In some networks (mainly complex ones), a set of enabling actors is important in order to protect the network from the unexpected

[15]As far as all the actors are connected to each other through the central actor (the star network), the planned network has high degree of centralization.

collapse due to withdrawal of the central actor. A similar analysis for planned network formation can be obtained also from both closeness centrality and betweenness centrality that exhibit a high degree of variance and high divergence between high and low actors (see table 1).

Table1: SNA indicators (actor related and the whole network elated) for Lyonbiopole innovation network.

Network	**2005**	**2006**	**2007**	**2008**
Degree centrality				
Mean	5.615	7.47	6.95	7.7
Variance	8.62	22.4	27.3	41
High degree	15	23	28	45
Low degree	2	2	1	1
Heterogeneity measure	4.90%	3%	2.21%	1.4%
Network centralization	40.67%	36.06%	30.93%	31.6%
Closeness centrality (Incloseness)				
Mean	46.41	45.7	17.55	34.9
Variance	62.53	53.13	16.9	37.13
High value	71.42	67.17	21.94	56.6
Low value	36.76	31.2	1.4	22.22
Network-in Centralization	53.10%	44.21%	---------	43.7%
Freeman Betweenness Centrality				
Mean	30.30	55.5	93.95	233.52
Variance	3276.25	15911.3	50168.3	557791.875
High value	222.16	567.5	1237.33	5668.7
Low value	0	0	0	0
Network centralization index	33.26%	26.43%	24.1%	38.38%
Density	0.2169	0.1589	0.096	0.0629
Average distance	2.21	2.235	2.48	2.91
Pointing connectivity	1-2 or 1-3	1-3 or 1-4 or 1-5	1-3 or 1-4 or 1-6	1-4 or 1-6 or 1-9
Clustering coefficient	0.772	0.746	0.768	0.76
# of Cliquishnesses	11	29	43	84

The network related measures also confirm the planned network structure. For example, the relatively low density implies that actors are constrained in the choice of channel through which they can exchange cognitive resources; therefore they may need for enabling actors to control the flow of cognitive resources with other actors, and to provide the stability for the network. The low distance (2.21) denotes that most of the actors are connected to each other with nearly “2 edges”, which means that most actors are connected to each other through one or group of actors who control the interactions or flow of information between network actors. Finally, the clustering coefficient (0.772) and number of cliquishnesses (11) show that there is a large amount of subgroups (11 cliquishness in Lyonbiopole) that are connected to each other through the enabling actors. This result about Lyonbiopole formation mode is consistent with the case study of ServPPINs in healthcare sector, tourism and KIBS (Weber, 2009, Sundbo, 2009) which are often defined as planned (top-down) networks.

Finally, it is important to point out that the enabling (key) actors in the initiation stage are mainly public actors (CNRS, Inserm, and Lyon1 University). This is consistent with the literatures of the life cycle growth model of many INs, where the initial stages of the life cycle is dominated by the public actors who are mainly represented by universities and public research centers.

2. Network dynamics

The INs are not static phenomena, they evolve, such as the interactions and structures of INs are in a permanently dynamic process (Lane and Maxfield 1997,2005). In other words, the state of the network in one period shapes (influences) the state of the system in the subsequent periods as it induces the dynamic process of cognitive resources and learning (Garcia-Pont and Nohria, 2002; Gulati, 1999; Powell et. al 1996). The dynamic or evolutionary process incorporates the entry of new actors and continuous changes in the variety and size of information that flows in the networks, as well as the distribution of power between actors. The new coming actors have different characteristics (incentives, competencies, etc); they share the cognitive resources so as to achieve their objectives. The behavior and preferences of actors in the network will change toward forming new cooperation (ties) so as to maintain and enhance the pace of innovation. To reach an efficient process of interactions, the objectives of the new actors should be consistent with the overall innovation objective of the network, which is to implement R&D and to provide health services (diagnosis, prevention and treatment).

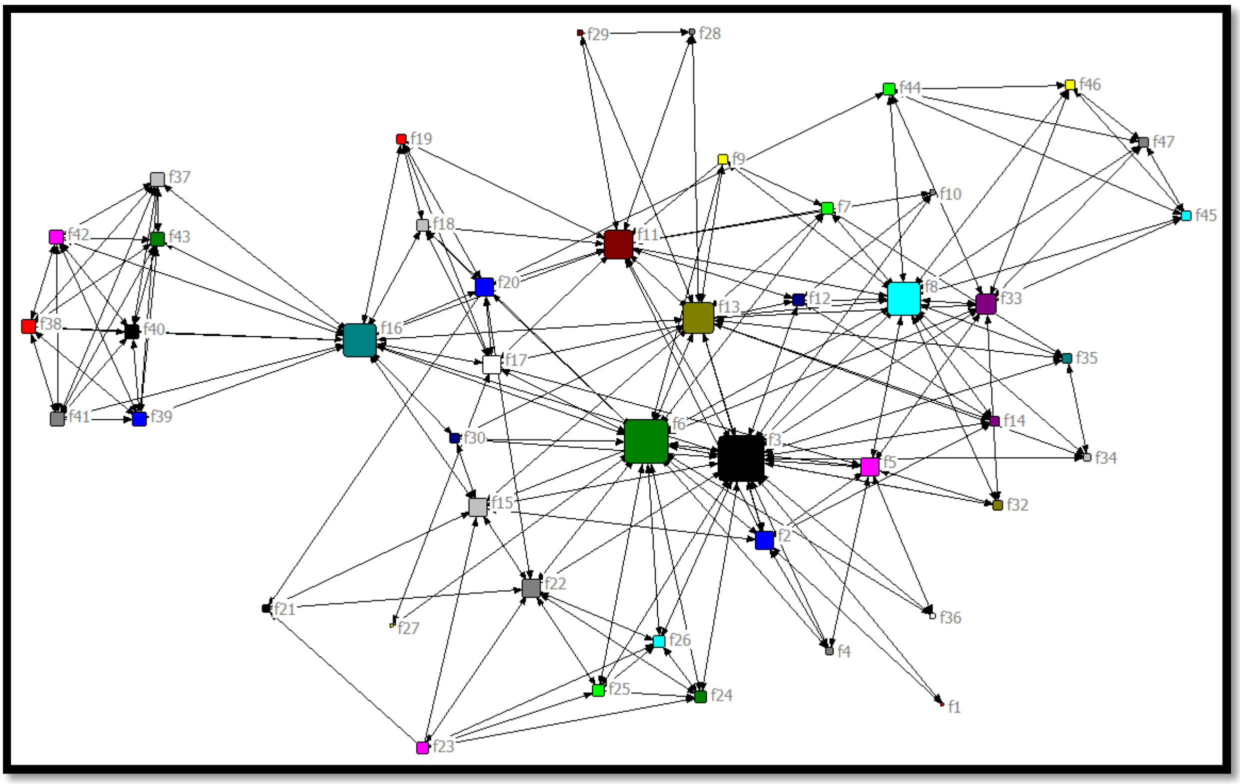
The networks literature has applied the product life cycle model to describe the dynamic of networks (Roloff, 2008; Weber, 2009; Sundbo, 2009; Pyka et al. 2010). The network life cycle model cannot predict the development of the network or if the network will pass through all the life cycle stages, but it is considered to be an important tool to "understand the aggregate evolution of certain networks" (Weber, 2009). We will assume that Lyonbiopole innovation network goes through three stage life cycles: formation, growth and maturity. The network was formed in 2005 and it continued to grow up till 2008 when the network arrived the maturity status. In 2008, Lyonbiopole was successfully evaluated by the government, therefore the government has launched a second phase of Lyonbiopole for additional three year from 2009-2011.

2.1. Lyonbiopole first growth stage in 2006

Generally, the planned network grows because of the initiative of the enabling actors, who possibly after consulting other members and on the basis of their recommendations, invite additional members to join the network. In the case of Lyonbiopole, the situation is a little bit different; calling for new projects by the founders is the main driver for network evolution (growth). The founders may not be themselves the planned actors. For example, CNRS and Inserm are two enabling actors in the initiation stage but not from the founded actors. The implementation of new projects means that new actors (new ties), and new interactions are included into the networks. So, when a network grows, the growth leads to a new network structure. New changes in the role of actors might happen, and different competences (e.g. knowledge and technologies) are likely to be exchanged, therefore, new innovation activities are implemented. We will reveal the network structure of 2006 using the same techniques (SNA indicators with graph theory) than for the initiation state (2005) (see figure 3).

In case of actor related measures (centrality measures), the overall degree of centrality equal 36.06%, closeness centrality equal 44.21% and betweenness centrality equal 26.43%. We see that these three values are all less than that in 2005 (see table 1). The decreasing of centrality power in the network is explained by the increase in the number of actors in the enabling group (CNRS, Inserm, UJF, Merial, Lyon1 University and BioMerieux) who have close values for degree centrality (see table3). In other words, the control power is re-distributed to include new enabling actors. Next to the group of enabling actors (the degree of centrality is greater than or equal 15), we find another group where the degree of centrality is less than or equal to 10 and it includes the rest of the network actors.

Figure3: Degree centrality for Lyonbiopole network at 2006



In a network related measure, the network's overall density (0.1589) is less than that of 2005, even though small increases in average distance (2.235) are found. The decrease in network density is consistent with the specificities of the planned network, where the stability of the network and the flow of cognitive resources are highly dependent on the enabling actors. The connectivity (1-3 or 1-4 or 1-5) is higher than that of 2005 because of the increase in the number of enabling actors, which gives more channels for the cognitive resources flow. Therefore, peripheral actors can interact using more than one intermediary of enabling actors, which has a positive effect on the stability and the speed of cognitive resources. Networks clustering coefficient equal 0.746, which might be explained by the high number of subgroups or cliquishnesses (29) which are connected to each other through the enabling actors and which give the network more cohesiveness.

The high number of cliques may lead to alow degree of clustering coefficient as far as each clique consists of a group of actors who are tied strongly to each other when compared to other network actors. But, the high clustering coefficient here denotes that the cliques (subgroups) are connected to each other through the enabling actors who in turn form a cohesive network. Table 2 confirms this result and shows that the enabling actors overlap with most of the cliques. These intermediary enabling actors work as a bridge between the different subgroups, which is crucial for the flow of cognitive resources between the different subgroups which are supposed to have different competences and a high degree of absorptive capacity.

The shift from a local-only (national) innovation networks to a global (international) one, and the increasing role of private actors (like Merial) in the process of innovation output are two important changes in Lyonbiopole in 2006. In the former, new interactions with international actors occur, which allow for the flow of new cognitive resources that may not be available from interaction with national actors. In the latter, the increasing role of private actors is expected because they enter the network to face the increasing demand for innovation output (medical services). For example, the enabling role of Merial is important, because of its high expected capabilities in providing new and diverse competences since it has branches in many countries around the world (e.g. Germany, USA and Canada).

Table 2: The above table shows the 29 cliques in Lyonbiopole innovation network in 2006. Here, the enabling actors: f3 (CNRS), f6 (Inserm), andf8 (UJF) have the high demonstration in the network subgroups (cliques).

clique	Participant actors	clique	Participant actors
1	f3 f5 f6 f8 f32 f33	15	f2 f3 f13 f15
2	f2 f3 f4 f5 f6	16	f3 f8 f13 f34 f35
3	f3 f5 f6 f36	17	f6 f7 f8 f9 f13
4	f3 f6 f8 f13 f33	18	f7 f8 f13 f35
5	f2 f3 f6 f13	19	f11 f16 f17 f18 f19 f20
6	f3 f6 f13 f16 f30	20	f11 f12 f17
7	f3 f6 f24 f25 f26	21	f6 f16 f17 f18 f20
8	f1 f2 f3	22	f6 f17 f27
9	f3 f10 f12	23	f6 f20 f22
10	f3 f11 f13 f16	24	f15 f21 f22
11	f3 f11 f12	25	f6 f22 f24 f25 f26
12	f3 f12 f14	26	f11 f13 f28 f29
13	f2 f3 f13 f14	27	f16 f37 f38 f39 f40 f41 f42 f43
14	f3 f8 f13 f14	28	f8 f33 f44 f45 f46 f47
15	f3 f13 f15 f16 f30		

Depending on the previous SNA for network in 2005 and 2006, we recognize that the degree centrality of the enabling actors (like CNRS and Inserm) increases between the initiation stage and first growth stage (see table 3), i.e. enabling actors in the initiation stage safeguard their enabling position in the growth stage. Accordingly, "preferential attachment"[16] is likely to be the closest growth pattern for Lyonbiopole, in which most of new actors connect themselves to the enabling actors. Direct connection with enabling actors, however, provides new actors with efficient access or short pathways to the knowledge and technologies that are present in the network. Therefore,

[16] It is a mechanism for describing the growth of networks, in which a new actor preferentially attracts himself to the actor with the highest degree (Barab´asi and Albert, 1999). In other words, "the probability that a new actor attaches himself to an existing actor is exactly proportional to the latter's degree" (Pyka et al.2010). This mechanism mainly leads to scale-free networks.

exchanged knowledge and technologies will flow more quickly in the network that picks up the pace of innovation.

2.2. Lyonbiopole second growth phase “2007”

In 2007, new expansion occurred for Lyonbiopole due to the initiation of new projects (see figure 4). A new set of private actors (like, Flamel technologies, Elicity1, Kalys, Top industry, Faure Ingénierie and CIAT) enters the network, which confirms what we have mentioned previously regarding the large number of private actors who enter the network in the growth state.

The centrality measures and the degree of heterogeneity (2.21%) are lower than those in 2005 and 2006 (see table 1), which indicates that Lyonbiopole experiences more distribution of power between network actors and new actors who gain more enabling powers or central positions. There are three main clusters in the case of degree centrality. The first consists of the central actors from previous stage (CNRS “f3”, Inserm “f6”, Lyon1 university “f13”, Merial “f16”, UJF “f8”) who also gained more power in this stage under the preferential attachment mode of attraction. The second cluster, consists of actors with medium degree centrality (ENS “f5”, Biomerieux “f11” or cluster which contains actors HCL “f22”, MBEL “f33”, Protein'eXpert “f15” and CHU Grenoble “f26”). The third one consists of the peripheral actors with low degree of centrality (INSA Toulouse “f35”, Kalys “f53”, ELYO Cylergie “f64”, Hôpital Edouard Herriot “f30”, INSA “f7”).

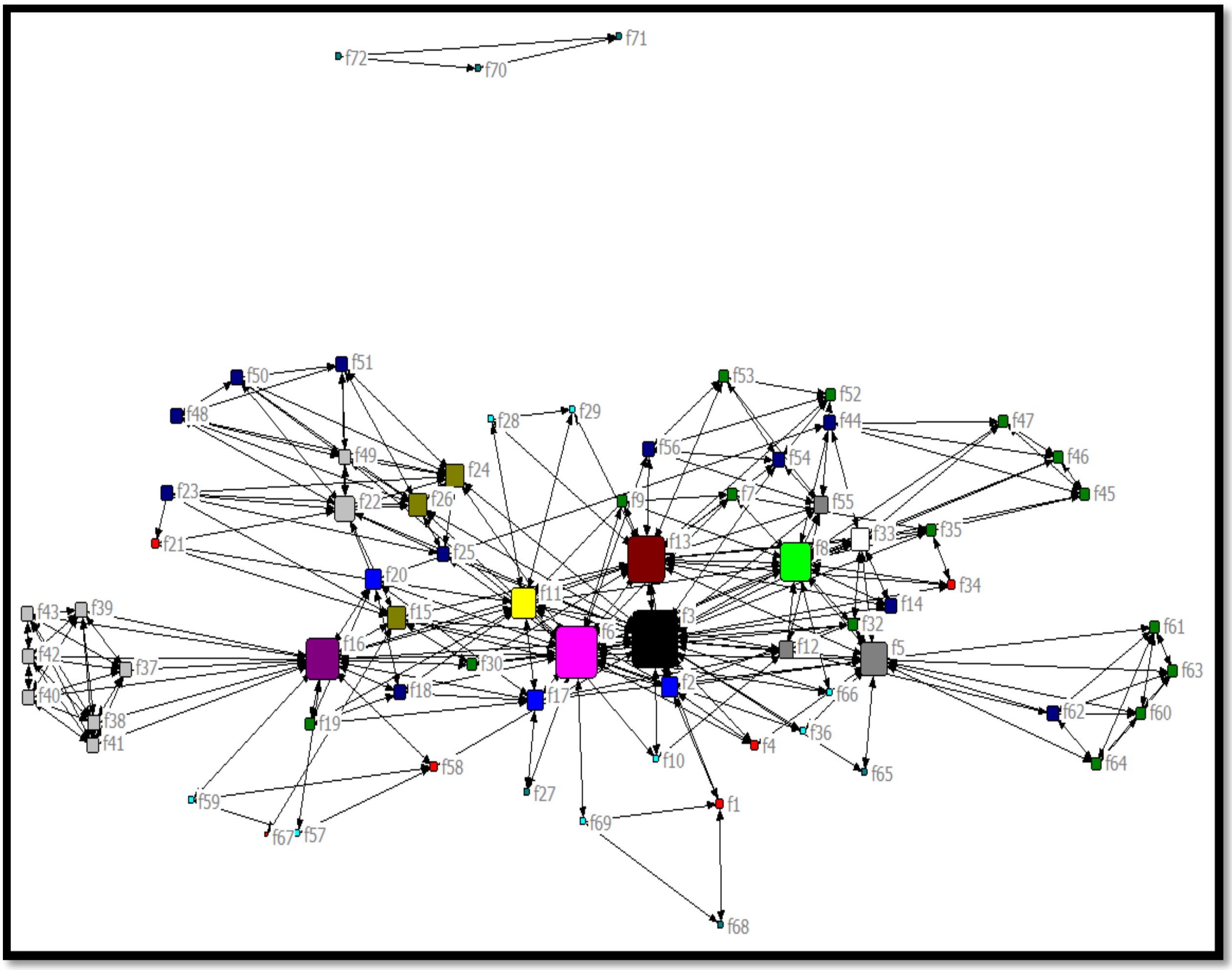
There is some kind of inconsistency between degree centrality and closeness centrality measures. Some actors like Edouard Herriot hospital and Maxio, who are considered peripherals in the case of degree centrality, are reference actors and have a strategic position in the network because of their high closeness centrality measures. This might be positive for the network as the roles of peripheral actors increase and they efficiently take advantage of the cognitive resources distributed.

In network related measures, the average distance (2.48) and point connectivity (6, 7 or 8 edges for some actors) showed an increase when compared to that of 2006. The increase in the connectivity is important as it offers alternative ways of exchange between actors as far as if an actor faces deficiencies in one path, he can use alternative one. In addition, the high point connectivity provides the network with more stability, and less dependency and vulnerability (Pyka et al.2010), and it allows for knowledge and information to be exchanged more quickly between network actors. The clustering coefficient is still high (0.768) when compared to 2005 and 2006, which is consistent with the high number of subgroups or cliquishnesses (43). The sharp decline in density measure is important to facilitate the consistency between the high number of cliquishnesses and the high measure of clustering coefficients, where high density could prevent the forming of subgroups inside the cluster.

Most of SNA measures (actor related measures and/or network related measures) for Lyonbiopole in the second growth phase denote that Lyonbiopole gains some of spontaneous network specifities. This means that Lyonbiopole is likely to experience a process of convergence between planned and spontaneous network in this stage. An important inquiry arises here about whether the convergence between planned and spontaneous network is beneficial for innovation process or not.

The answer is yes. Firstly, the trend to more spontaneous interactions is crucial in this growth stage, where high numbers of interactions, diverse competences, and large amount of social capital and innovation processes are important to fill the gap between actual and potential demand. The planned network lacks the informality and trust that are important for the learning process and the exchange of competences between network actors; therefore, the spontaneous interactions are important to provide open and collaborative cultures that are vital to facilitate the process of exchanging knowledge and technologies (Weber, 2009). Secondly, the distribution of power (degree centrality) between variables and the more central position of peripheral actors lead to a new diversity of cognitive resources, for example, access to new competences other than complex knowledge and technologies that universities and research centers (like CNRS and Inserm) provide is important to produce non-technological innovation outputs. Thirdly, the spontaneous interactions provide more channels and speed for the exchange of competencies through the network, and they enhance the stability of the network.

Figure 4: Degree centrality of Lyonbiopole Network at 2007



One of the remarkable points in this second phase of growth is the high interaction with hospitals (Cantonal of Genève Hospital. CHUV de Lausanne, AP-HP, Hôpital Edouard Herriot, CHU de Grenoble and HCL). This might be important for the innovation processes, because the high interactions between hospitals actors (doctors, nurses, patients, etc) facilitate the mobilization of knowledge and information which are needed to produce appropriate diagnosis, treatments or preventions. For example, therapy companies use the knowledge and information gained from the interaction with hospitals to develop new products (like vaccine, diagnostics, and drug delivery systems).

2.3. Lyonbiopole in the maturity stage "2008"

In this stage of the network evolutionary path, Lyonbiopole reached its maturity status. In general, the maturity stage is described by high number of private firms, well articulated demand, and intense competition since most actors try to increase their market shares. In the case of innovational capabilities, the maturity stage is characterized by intensive interaction between actors who generate high amount of social capital and high amount of knowledge and information which are diffused in the network (Pyka et al. 2010).

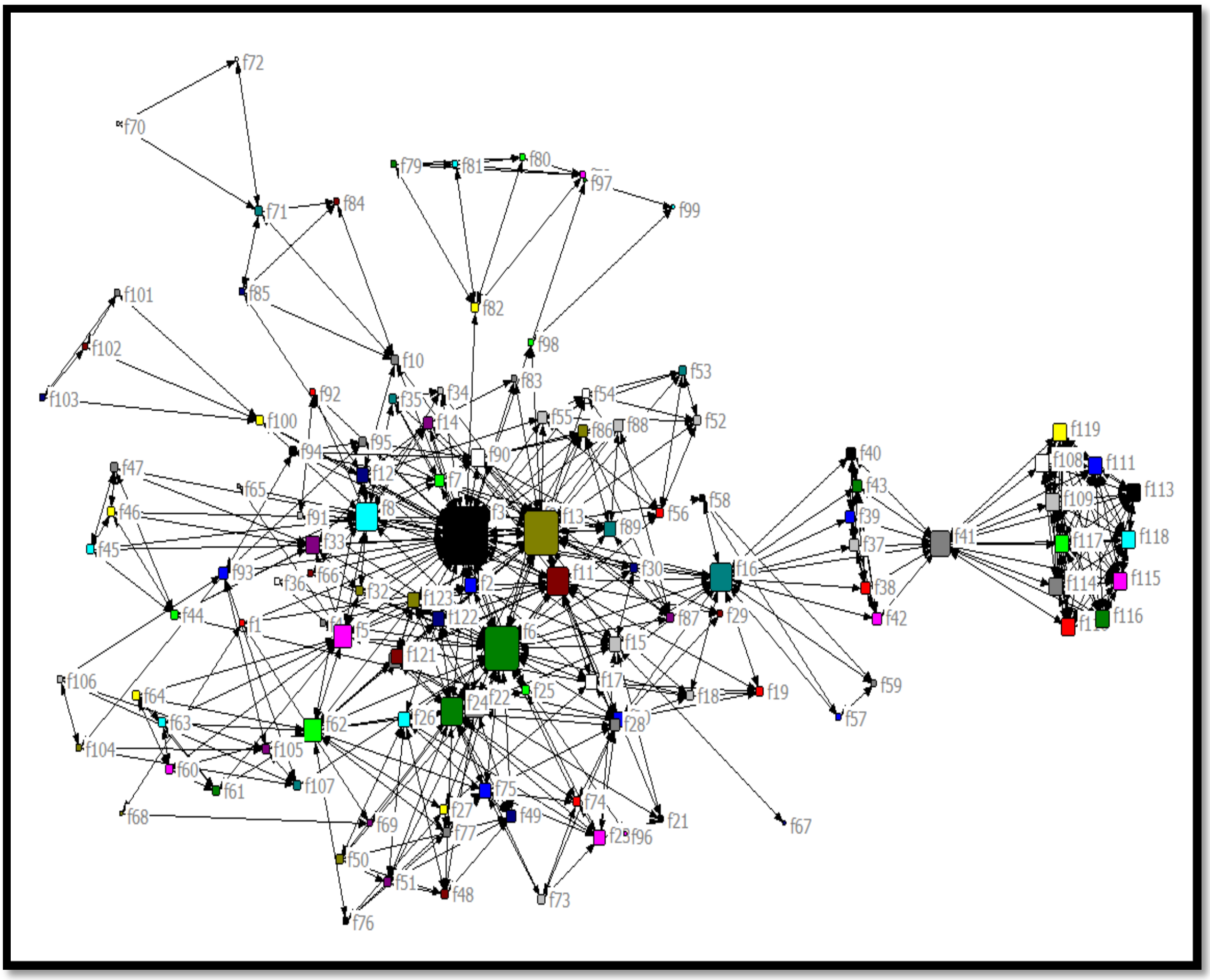
Using SNA and graph theory, we notice that the overall degree of centrality (31.6%) had increased a little. This may be due to the increase in the enabling (control) power of some previous central actors mainly CNRS, Inserm and Lyon 1 University (see table 3 and Figure 5) i.e. public institutions for Research. This result is not coherent with the characteristics of innovation networks in the maturity state which displays a shift in the power towards the private actors. It also shows that complex technologies from public actors are also vital in this maturity state. This may be explained by the need for public organizations to provide new cognitive resources or technological discontinuities that prevent a network to start declining and that lead it to start a new life cycle within the same industry (Tushman and Anderson, 1986). The launching of the second phase (2009-2011)[17] of Lyonbiopole by the French government confirmed this hypothesis. The measures of closeness and betweenness centrality have increased compared to those in 2007, which means that the actors in the network have become well situated (positioned), vigorous for the control of information flow in the network, and having more opportunity to access knowledge and technologies.

[17] Due to the extension of Lyonbiopole to new period form 2009-2011, the network does not continue to the decline stage, instead further innovation or technological discontinuities lead to the initiation of new cycle in the same industry.

Many of the actors who have the highest value of closeness centrality and betweenness centrality in Lyonbiopole are considered peripheral regarding the degree of centrality. For example, the group of actors with highest closeness centrality (f3 "CNRS", f16 "Inserm", f13 "Lyon 1 university", f16 "Merial", f11 "Biomerieux" and f15"Protein'eXpert", F30 "Hôpital Edouard Herriot") include actors with low degree centrality, which means that some actors in this group are well positioned in the network and more important in the distribution of information with other network actors. The same discussion can be applied to the group of actors with highest betweenness centrality (F3 "CNRS", f16 "Merial", f6 "Inserm", f41 "Laboratory of Weybridge" (UK), f13 "Lyon1 university" and f82 "Laboratoire de Chimie des Molécules Bioactives et Arômes(LCMBA)"), where actors like Laboratory of Weybridge and LCMBA have a high degree of social capital and are therefore important in the control of information flows through the network as well as working as broker (structural holes) between separated subgroups. In spite of that, they have a medium (media) or low degree of centrality.

In the case of network related measures, we find that point connectivity and number of cliquishnesses increased, and network clustering coefficient is still high and has witnessed no significant change (see table1) compared to 2007. The doubling of the cliquishnesses number is likely to be one of the success factors in Lyonbiopole in the maturity state. Cliquishnesses provide a high social capital and also a high absorptive capacity, which are important for the production and quick diffusion of knowledge and technologies for the facilitation of collaboration between factors and the enhancement of system performance and knowledge diffusion (Uzzi and Spiro, 2005; schilling and Phelps, 2007). The increase of the connectivity points and of the number of cliquishnesses confirms the characteristics of the network at maturity stage, which is supposed to have a high amount of knowledge and high technological competencies to launch the second wave of Lyonbiopole.

Figure 5: Degree centrality of Lyonbiopole Network at 2008



The density of Lyonbiopole is very low, which can be explained by the fact that Lyonbiopole in this stage consists of high number of cliquishnesses (subgroups). Accordingly, the network density is likely to be a misleading indicator for network cohesion, through the false impression of weak network coherence, while the coherence is entirely internal to the subgroups (Friedkin, 1981). The low value of density might hamper the stability and speed of information flow in the network. In this case, the enabling actors who usually frequent in many subsectors and work as a bridge between many of the network cliques, play a crucial role in the exchange of knowledge and technologies between different subgroups and throughout the whole network.

Table 3: The factors with the highest "degree centrality"

	Degree centrality In 2005	Degree centrality in 2006	Degree centrality in 2007	Degree centrality in 2008
CNRS "F3"	14	22	27	45
Inserm "F6"	11	21	25	34
INRA "f2"	9	9	9	9
UJF "F8"	4	17	19	21
BioMerieux "F11"	10	14	14	20
Lyon1 "F13"	7	16	22	35
Merial "F16"	5	17	20	20
HCL "F22"	7	7	11	18
Transegen "F24"	6	6	10	21
Agence Laboratoire Vétérinaire "F41"	_	7	7	18
ENS "F5"	4	9	16	16

2.4. Success factors in Lyonbiopole

The performance of Lyonbiople is determined by its ability to achieve its goal as a healthcare shield which produce innovation output in the fields of vaccines and diagnostics. Knowing that Lyonbiopole was evaluated in 2008 by government as a successful IN, then there are success factors that contribute to the success of collaboration processes and the mobilizing of cognitive resources which have led the network to the maturity state and then to successful innovation output.

2.4.1. Private and public role in the success of Lyonbiopole

Here, we will make a comparison between public and private actors' roles in the development of innovation in Lyonbiopole. This comparison might be important for policy making to find the efficient innovation tools and policies. Different policies might be needed for different actors. For example, policies for prompting R&D activities through universities and public research centers might be different from those required for prompting non-technological activities (like, internal organizational changes, marketing strategies and interaction with consumers).

If we look back at the enabling actors in the maturity state (see table 3), we find that the three actors with the highest degree centrality (degree centrality greater than 30) are public actors (CNRS, Lyon 1 University and Inserm) and most of the network actors are directly connected to these three actors (see figure5). This means that the competencies of these three actors and the flow of information between them and other network actors are vital for the production and diffusion of new cognitive resources. CNRS and Lyon 1 University are academic institutions for science and technology and they produce new knowledge and technologies (like R&D) required by other network actors, while Inserm is a public research institute for science and technology entirely dedicated to produce new knowledge about human health. Accordingly, to enhance the innovation capabilities of Lyonbiopole, founders are preferred to use strategies that facilitate and encourage the cooperation with the above public actors.

Private actors are also having a prominent role in the process of innovation through a group of private enterprises (e.g. Transegen, Biomerieux and Merial). This group belongs to the second group of enabling actors (including actors with degree centrality between 16 and 21), thus, they have less ties with other network actors than the first group of enabling actors. These private actors are important in commercialization (growth stage) and consolidation (maturity stage) to face the increasing demand for innovation output (new diagnostic solutions that may include instruments and software, medicines and vaccines as wellas treatments). Private actors cooperate very highly and interact with the public enabling actors to access complement knowledge and technologies, and also exchange information with non-central actors (actors with small degree centrality) like hospital, medical laboratories and institutes.

By using a betweenness centrality measure, we find that the private actor Merial is better positioned (have less distance to the other network actors) in the network than public actors like Inserm and Lyon 1 University. In other words, through Merial, the information can be distributed to the other network actors more efficiently than in the case of Inserm and Lyon 1 University. It means that Merial has a more vital role in the success of innovation process. Using closeness centrality shows the same result with regard to the enabling group of public actors (CNRS, Inserm and Lyon 1 University) which is the most efficient in receiving or distributing information. The group of private actors (Protein'eXpert, BioMerieux, Merial and Transgene) also plays an important role but less important than the public actors.

Overall, the existing of both public and private actors as enabling actors is important for the success of innovation process since heterogeneous competencies (technological and non technological) are introduced in the process. The technological competences that are mainly produced through universities and public research centers are not always sufficient for the efficiency and success of the innovation processes. The private actor competences are also important as the "healthcare shield" requires both complex technologies and other private (manufacturing and services) innovative activities (like diagnostic solutions "reagents, instruments and software", treatments and vaccines to improve the health, prevention strategies, new approaches to human and animal infectious diseases, and new organizational and administrative changes). This is consistent with Weber (2009) hypothesis that states when the network is led by both combined public and private or by semi-public leadership it has a high propensity to reach the third stage of its life cycle.

2.4.2. The cooperation with international actors

Lyonbiopole has also witnessed collaborations with international actors all over the life cycle. International actors consist mostly of universities and institutes for animals health (Friedrich Loeffler Institute in Germany, Scottish Agricultural College and University, Clondiag Germany, Institute of Animal Health in UK and Weybridge in UK). The interactions with international actors are expected to provide cognitive resources not available on a national basis.

2.4.3. Forming of small-world network

Some network structures are more beneficial for innovation than others (Uzzi and Spiro, 2005; Burt, 2004). For example, Innovation network with small-world structure is supposed to have more positive influence on innovation output than other network structures like random and regular networks (Watts 1999; Hargadon 2003; Cowan and

Jonard 2003, 2004; Schilling and Phelps 2007). It facilitates the coexistence of dense and clustered relationships and of distant and weak relationships (Fleming et al. 2007), which are important for the exchange of knowledge and technologies between the actors of the network.

Networks dynamics might lead to a different form of network structures, where a diverse innovation output might be found. Regular network, random network and small-world network are three important network types (Watts and Strogatz, 1998). In the first, each node is connected with its neighbors and it exhibits high clustering and long path length. In the second, nodes are randomly connected to each other and they exhibit a low clustering coefficient and a short path length. In the small-work network, Watts and Strogatz (1998) tried to find an intermediate network between these two extreme networks. They combined between high degree of cliquishnesses of regular network and short path length of random network in a small-world network. Here, we focus on two network-related measures; path length and clustering coefficient to show how they lead to a network structure that is similar to small-world network.

Through Lyonbiopole life cycle (from initial stage to maturity stage), the clustering coefficient continues to be high (more than 0.70 in all stages) with an increase in the cliquishnesses number. The path length (average distance) is relatively small despite the slight growing along life cycle stages (see table 1). Less than 3 connections on average are needed to pass information from one actor to another. Thus, related to Watts and Strogatz (1998), Lyonbiopole may be considered as a small-world innovation network like many real-worlds INs. Furthermore, the preferential attachment mechanism which describes the growth of Lyonbiopole through the life cycle model has led to the formation of a power-law[18] that has led to a small-world IN. It is important to note that sometimes the high measurements of clustering coefficient

[18] Powe law is "a special kind of mathematical relationship between two quantities. When the frequency of an event varies as a power of some attribute of that event (e.g. its size), the frequency is said to follow a power law"(Wikipedia).

and low distance lead to too much small worldedness network which lead to redundancy in information and reduced novelty (Uzzi and Spiro, 2005).

The small-world nature of Lyonbiopole was crucial to the success of innovation through its vital role in efficient production and the diffusion of cognitive resources, taking into account that a high amount of complex technologies is required in the maturity state for launching the new circle of Lyonbiopole life cycle. A small-world structure also provides high amount of social capital that facilitates the trust, and improves the efficiency of collaboration between heterogeneous actors (universities, hospitals, research centers, industrial firms and service firms) who have different competencies and preferences. It also allows the coexistence (integration) between the high number of cliquishnesses and the formation of a cohesive network with a consensus between different subgroups. Nevertheless, it is important to take into account the behavior of actors and interaction processes that might make the finding of relationships between small-world networks and innovation a difficult work.

Conclusion

The case study discussed in this chapter represents an empirical application of the ServPPIN concept and more precisely of a public private innovation network settled to produce architectural or complex innovation (both technological and non-technological innovation). Our conceptual framework which contains the four main elements for addressing the innovation in public-private innovation networks (heterogeneous actors, social interactions, dynamic growth and network life cycle model) is applied on Lyonbiopole innovation process. The combined application of a product life cycle model and measures from social network analysis enables us to describe the formation, characteristics and structure of Lyonbiopole and its dynamics.

The public actors (e.g. CNRS, Inserm and University of Lyon1) not only have a central role in the initiation stage, but they also have the control role through the growth and maturity stage despite the parallel increase of the private role. This confirms the need of firm to acquire complex knowledge and technologies that universities and public research centers are able to provide along the whole life cycle of the network. In a maturity stage, technological competences are highly demanded so as to avoid the decline of network and to allow the launching of a second life cycle of Lyonbiopole from 2008 to 2011. Extreme dependency on complex technologies might hide the important role of non-technological competences (e.g. consumers' competences, organizational and marketing competences) in the success of Lyonbiopole, as a "healthcare shield" to coordinate a comprehensive approach to human and animal infectious diseases covering diagnosis, prevention, treatment and innovative administration systems.

Finally, the structure of Lyonbiopole at the maturity state, that reflects the formation of a small-world network, has a crucial role in the success of the innovation output. Small-world structure provides an efficient exchange of knowledge and technologies, a high amount of social capital which facilitates the trust and improves the efficiency of collaboration between heterogeneous actors (like, universities, hospitals, research centers, industrial firms and service firms) who have different competencies and preferences. It allows for the coexistence (integration) between the high number of cliquishnesses and cohesive network with consensus between different subgroups.

Chapter 6: Public-private innovation networks and innovation activities in French service firms

Introduction

As shown in chapter 3, innovation networks (INs) are cooperation relationships in which heterogeneous actors (e.g. firms, government agencies, universities, research centers, etc.) combine diverse knowledge and skills in order to create technological innovation. The development of innovation networks (INs) is linked to the rise of "Open Innovation" strategies and also to the use of complex technology which means that firms (even the most innovative ones) are unable to meet an increasing demand for knowledge using their own internal resources alone. Consequently, innovative firms rely on external resources (outside their own services) to supply their knowledge and technological competences (Hagedoorn et al., 2000; Bayona et al., 2001; Tether, 2002; Miotti and Sachwald, 2003), share costs and reduce the risk associated with the innovation process.

A review of the empirical literature on INs and cooperation relationships (mainly R&D cooperation) shows that most works are devoted to innovation in the manufacturing sector (Hall et al., 2000; Miotti and Sachwald, 2003; Faems et al., 2005). Moreover, despite taking public-private cooperation into consideration, IN literature mainly focuses on the cooperation between private organizations or actors (cooperation with competitors, suppliers, etc.), i.e. on "private-private INs".

After the first contribution in chapter 5 (Lyonbiopole ServPPINs), this paper is the second empirical application in this thesis regarding the contribution of service firms to INs and the importance of collaboration with public agents. Lyonbiopole case study provided a real example of the innovation process under the conceptual framework of ServPPINs developed in chapter 4. Chapter 6presents an estimation of the effect of cooperation for innovation in services (ServPPINs) on innovation output (product, process, organizational and marketing innovation) i.e. an evaluation for the importance of the relationship between cooperation for innovation and innovation output.

Because of the limitation of data, we focus our study here on public participation through universities, higher education institutions and public R&D centers. As we have discussed in chapter 3, these public actors are the main source of complex knowledge and technology. Thus, related to the four ServPPINs types discussed in chapter 4 our discussion here is focused on the estimation of the cooperation effect on innovation in the case of ServPPINs.

We start this work by comparing three types of cooperation strategies:
1)Service firms which cooperate solely with other private partners (e.g. consumers, suppliers and rivals) to -form "private-private INs".
2) Service firms which cooperate solely with public actors (e.g. universities and public research centers) to form "strict public-private INs".
3)Firms which cooperate with both public and private actors, forming "extensive public-private INs".

The chapter is then organized as follows. In the first part we discuss a certain number of key theoretical and empirical arguments concerning the relationship between innovation behavior and the strategy of cooperation for innovation by considering two cooperation strategy modes: cooperation with private actors (consumers, suppliers, competitors, etc.) and cooperation with public actors (universities, public research centers, etc.). We also address the spatial dimension (national vs. international) of the network. In the second part, we analyze the cooperation (with both private and public actors) strategies deployed by service firms in their innovation activities, using CIS4 data. We measure the effect of cooperation between private firms and public actors on the innovation outcome, and compare it with cooperation with private actors. We also compare the effects of cooperation strategies (innovation networks) in the service and manufacturing sectors. In the third part, we summarize the result of the empirical analysis of the cooperation for innovation strategy in service firms and provide appropriate recommendations. In the fourth part, we provide the empirical result for the comparison between services and manufacturing firms in regards with cooperation for innovation.

1. Key theoretical and empirical cooperation for innovation arguments

The aim of this section is to review the theoretical and empirical background of cooperation for innovation, and its influence on firms' innovation activities. INs can be embedded in services in different forms: INs with homogeneous actors (e.g. private actors from the same business lines or private actors from the same sector), INs with heterogeneous actors (public and private actors), national INs in which all partners operate in the same country, and international INs in which partners are from other countries or world regions.

Most of the empirical literature focuses on intensive technological innovation R&D (Fritsch and Lukas, 2001; Tether, 2001; Negassi, 2004; Nieto and Santamarıa, 2007; Segarra-Blasco and Arauzo-Carod, 2008; Silipo, 2008; Tsai, 2009; Robin and Schubert, 2010) and addresses a wide range of issues related to R&D and innovation cooperation (e.g. determinants, motivation, obstacles, economic impact, and the different impacts for innovation partners). Very few studies focus on the specific nature of cooperation for innovation in services (Tether, 2002; Tether and Tajar, 2008). This might be explained by the novelty of such types of cooperation in those sectors and the lack of data on such cooperation.

1.1. Heterogeneous cooperation partners

Complex technologies are the main outcome of innovation networks (Rycroft & Kash, 2004). Various skills and competencies may be required in such situations that would not otherwise be available without the involvement of different partners. Each partner in the network has a specific role to play and is expected to have distinct effects on the innovation outcome (Nieto and Santamarıa, 2007). As such, finding proper partners to maximize the cooperation effect is a strategic decision for cooperative agreement (Cyert and Goodman, 1997; Doz et al., 2000; Arranz and Arroyabe, 2008). Different strategies may be used to measure the effect of the network, depending on how the network actors are classified. By measuring the effect of each actor separately, for example, or by breaking down actors into horizontal and vertical cooperation, public and private actors, or the geographical location of the partners (e.g. national and international). In this paper, we focus on the breakdown of actors into private and public partners. We therefore distinguish between the two following types of networks: "private-private networks" that include only private partners and "public-private networks" that include both public and private partners.

The literature highlights the positive relationship between the partnership mode and innovation performance. Fritsch and Lukas (2001), based on a sample of German manufacturing companies, found that cooperation with suppliers leads to a low value-added to turnover ratio compared with other partners. This is explained by the fact that the resources gained from cooperation with suppliers substituted rather complemented internal resources. Segarra-Blasco and Arauzo-Carod (2008), examining innovative Spanish firms (manufacturing and services), found a degree of complementarity between cooperation partners (such as complementarities between universities and clients).

1.1.1. "Private-Private Cooperation" strategies

The literature on this subject generally distinguishes between three types of private partners, each with specific characteristics (competencies, resources and strategies, etc.) and complementary assets which drive other partners to cooperate. The first one is the consumer - a key link in the supply chain - who provides information on needs and ideas for innovation. Cooperation with consumers is crucial in alleviating the risk of introducing complexity and novelty into the market innovation output or that associated with introducing innovation into a poorly-defined market (Von Hippel, 1988; Gardiner and Rothwell, 1985; Tether, 2002). Secondly, suppliers are another crucial external source of information. Cooperation with suppliers is the subject of much discussion "in the context of 'make or buy' decisions" (Tether, 2002), which goes beyond the objective of minimizing the cost of developing new knowledge and technologies. Suppliers have a vital role to play in the innovation process throughout the supply chain (Schiele, 2006). They are an important element in dealing with the major changes associated with the innovation process, such as changes in consumer references and shortening product lifecycles(Fossas-Olalla et al., 2010). The nature (type) of relationship between a firm and its suppliers is determined by several factors including the level of communication, the length of the cooperation relationship, the objective of the cooperation and the degree of dependence (Fossas-Olalla et al., 2010).

Competitors (rival firms) represent the third type of private partner innovation. As it becomes easier and faster to duplicate new products, cooperation with competitors is becoming crucial for firms in order to share the costs and risks of developing easily copied technologies. Cooperation with competitors is also discussed outside the transaction cost framework. In this perspective, Tether (2002) mentions three situations beyond the cost-saving debate: firstly, actors may cooperate in order to introduce products or services based on common standards. Secondly, cooperation may be partial, i.e. firms cooperate on some elements of the output depending on complementary weak and strong points. Finally, competitors collaborate to solve common problems that are not related to competition.

Empirically, Zeng et al. (2010), based on a survey of 137 Chinese manufacturing SMEs, found that cooperation with suppliers and clients plays a more significant role in innovation than horizontal cooperation with research institutions, universities and government agencies. Veugelers (1997); Fritsch and Lukas, (2001); Arora et al., (2001) and Tether (2002) found that R&D cooperation with customers, suppliers and competitors had a positive influence. Alvarez et al. (2009), using data from the Spanish manufacturing sector, found that cooperation between competitors tends to have a greater influence on company performance compared to other partners. In contrast, Whitely (2002), Miotti and Sachwald (2003), Nieto and Santamarıa (2007) reported that cooperation with suppliers, clients and research organizations has a positive effect on the novelty of innovation, but a smaller or negative effect in the case of cooperation with competitors (rivals).

1.1.2. "Public-Private Cooperation" strategies

Public partners can also be an important source of knowledge, and public-private networks may offer an efficient strategy to enhance innovation. It is useful to differentiate between strictly public-private INs where firms interact solely with public actors (e.g. universities and public research centers) and extended public-private INs where firms can cooperate with both public and private actors. Therefore, in extended public-private INs, private knowledge and technological resources (e.g. private research centers, consultants and rivals) along with public resources can provide a complementary source of knowledge for firms' internal knowledge capabilities.

The importance of direct public participation (cooperation) in innovation has been confirmed by numerous works (Mayntz, 1997; Messner, 1998; Morgan and Nauwelaers, 1999; Nauwelaers and Wintjes, 2003). Interactive modes of public intervention and associational forms of governance (e.g. public decisions, actions and arrangements) are likely to improve innovation performance compared to traditional public intervention (top-down policy strategies). This explains the pressure that public actors experience in developed countries to move closer to industry.

Public actors are present in several forms, including universities, public research centers, and government agencies. Each of them has particular characteristics that may be a source of specific scientific and technological knowledge (Lundvall, 1992; Nelson, 1993). For example, universities and research institutes are important entities for the creation and dissemination of scientific knowledge (Hemmert, 2004). They have a high level of research potential and diversity and play a vital role in the economic competitiveness of countries (Archibugi and Coco, 2004). Universities are also important, since the focus of interest is on original path-breaking developments, whether in science or technology (Etzkowitz, 2002). In most industries, the role of universities is important in the transfer of know-how from laboratory to industry (Dessy, 2006).

Government agencies are also important public actors. Firms cooperate with them so as to benefit from public tools, which complement or overcome their internal deficiencies, to take advantage of public financial resources, as a complement to private resources, and to overcome old routines and policies by adopting new approaches, governmental roles, and new types of intervention tools (Toedtling and Trippl, 2005). The government's role in the innovation process is mainly focused on the creation and maintenance of a legal environment conducive to private sector investment in innovative activities (legal competencies and policy interventions) (Leyden and Link, 1992).

Arranz and Arroyabe (2008) point out that innovative Spanish firms have a high cooperation ratio with public actors: 16% for government and 18% for universities. They found that vertical cooperation is more efficient when firms seek to overcome market and technological risks and cooperate with public partners to obtain financing mainly for the high-mid-tech sector with limited technological resources. Others found that collaboration with research institutes and universities positively affects product innovation performance (McMillan et al., 2000; Vuola and Hameri, 2006; Monjon and Waelbroeck, 2003; Faems et al., 2005). Belderbos et al. (2004) found that incoming source-specific spillovers are weaker in the case of cooperation with competitor firms, while institutional spillovers have a positive impact on all modes of cooperation. In contrast, some authors found that collaboration with universities and research institutes has a negative effect on product innovation performance (Monjon and Waelbroeck, 2003; Caloghirou et al., 2004).

1.1.3. National and international cooperation

Firms currently cooperate not only with regional or national firms, but also with international organizations. Given the complexity of the innovation process, the greater number or deployment of ICTs[19], an increase in international competition, the need for firms to enter new markets and countries and to comply with different rules and regulations in other countries, firms need a high level of involvement in innovative activities, mainly on a global scale. This cannot be achieved without collaborative activities on both domestic and international levels. These international cooperation strategies do not differ from national ones, since they may take many forms, such as alliances, joint ventures, networks, etc. Since the beginning of 1990s, international cooperation relationships have represented the majority of overall collaborative relationships (Rycroft, 2007). There are two international relationships for every domestic one (Kang and Sakai, 2000). Policy makers also encourage international cooperation through their support systems.

Empirically, academics also differentiate between national and international cooperation, since cooperation with international firms can be a source of new ideas that are not found in the domestic market (Liefner et al., 2006). For example, Miotti and Sachwald (2003), building on data from the French CIS2, revealed that cooperation with US partners is more efficient than cooperation with EU partners mainly in sectors where the US has a comparative advantage (high-tech). Arranz and Arroyabe (2008) found that national and European cooperation for Spanish firms is more important and significant than cooperation with the US and Japan. Segarra-Blasco and Arauzo-Carod (2008) consider that national or international cooperation

[19] ICTs have an important role to play in reducing communication and coordination costs and increasing the possibility of coordinating activities at international level (Faria & Schmidt, 2007).

(EU) depends on the source of funding. When the funding is from the EU, then the cooperation is more international.

The importance of cooperation with international actors was discussed in chapter 5 where Lyonbiopole ServPPINs included international public and private organizations from UK, Germany, etc. These international actors were important to acquire cognitive resources not available on national level (in France).

1.2. The relationship between cooperation and innovation outcome

High innovation performance is generally associated with a high level of cooperation (network-based cooperation, Rycroft, 2007). Through cooperation, firms can access new knowledge, technological resources and know-how (Tyler and Steensma, 1995) that lead to extensions of their knowledge and technological capabilities and the development of new innovation products. The positive influence of networking behavior on boosting innovation output was confirmed by many studies (Powell, Koput and Smith-Doerr, 1996; Ahuja, 2000; Powell and Grodal, 2005; Veugelers, 1997; Calia et al., 2007; Porter and Ketels, 2003; Becker and Dietz, 2004).
The impact of cooperation strategy on innovation outcome can be discussed on two levels: innovation input and innovation output (Becker, 2003 and Becker and Dietz, 2004). In terms of innovation input, a firm's adoption of external knowledge through external partners increases its technological capabilities and improves its skills. The decision to cooperate with external resources is determined by the cost of the internal development of knowledge and technology compared to their costs from external resources. In other words, an efficient cooperation strategy for new technologies is possible if the cost-benefit relationship (trade-off) of accessing those technologies is positive (Becker and Dietz, 2004). In terms of innovation output, the greater the development of new knowledge and technology, the higher the probability of realizing innovations.

The nature (type) and number of cooperative actors (innovation network actors) are likely to have a crucial influence on the degree to which the cooperation effect impacts on innovation outcome (Vinding, 2003 and Becker and Dietz, 2004). In other words the innovation outcome differs according to the change of the cooperative partners. It is to be expected that in a network for producing new complex technologies, cooperation with universities and research centers is more vital than cooperation with actors who have low technological capabilities, while cooperation with consultancy firms is more efficient in a network for producing new solutions for clients. When more actors belong to the network, then more knowledge and technological opportunities might be available for network actors, thereby influencing their innovation capabilities and the realization of new products.

Many empirical works have tried to measure the impact of different types of cooperation networks on either the performance of innovative firms or on the economy as a whole. The result is inconsistent. It was positive and significant for a large number of firms, but insignificant or negative for others. For example, Brioschi et al. (2002); Becker and Dietz (2004); Nieto and Santamarıa (2007) revealed how the implementation of additional external capabilities has positively affected the realization of innovations. In Japan, Fukugawa (2006) explained how networking contributes to the speeding up of innovation and allows firms to access external expertise and resources. Hewitt-Dundas (2006) in a similar work showed how innovation cooperation with external actors in SMEs provides firms with the resources and capabilities that might supply them with the stimulus and capacity to innovate.In contrast, Larsson and Malmberg (1999) found no evidence for a positive relationship between technological cooperation and firm performance, in terms of the level of technology or innovative capacity. Fritsch and Franke (2004), using data from three German regions, found that cooperative relationships cannot provide the level of knowledge spillovers required for efficient innovation activities.

2. Empirical model, data and estimation method

As we mentioned earlier, we will use the available data on cooperation for innovation from the fourth community innovation survey (CIS4) -which was employed in chapter

2- in order to explore the significance of innovation cooperation for French innovative service firms, i.e. the relationship between cooperation for innovation and the introduction of four types of innovations (product, process, organizational and market innovation). We will take into account the fact that innovative firms are able to pursue different types of strategies for cooperation. For example, as regards the character of cooperation partners (public or private), firms can cooperate with public actors, private actors, or both in order to enhance their innovation output. Moreover, firms can share knowledge and technologies with local, national or international partners, i.e. they can form a national or a global innovation network.

Before we estimate the relationship between cooperation and innovation, we will provide some descriptive statistics about the dependent and independent variable that will be employed in the model.

a. Dependent variables

There is no consensus as regards the most relevant innovation performance index for measuring innovation performance (Zeng et al. 2010). It has been measured in the literature using different indicators such as proportion of annual turnover of new products (Zeng et al., 2010), the new products index (Fischer et al., 2001; Romijn and Albadalejo, 2002; Todtling et al., 2009; Zeng et al., 2010), sales of innovative products (Miotti and Sachwald, 2003; Negassi, 2004, Tsai, 2009) and the value-added to turnover ratio (Fritsch andFranke 2004). For our purposes, we have used the innovation output index where a firm's innovation output is represented by four dummy variables. Each of these variables is equal to one if the firm introduced a product, process, market or organizational innovation, respectively, between 2002-2004. Non-technological (market and organizational) innovation types which are important in services are taken into account.

Table one shows the share of firms introducing different types of technological and non-technological innovations in both service and manufacturing firms. Service firms introduce all types of innovation activities with a considerable tendency toward organizational innovation (nearly 40%). This is consistent with the fact that non-technological (disembodied artifacts) activities are the most important innovation activities in service innovation. Manufacturing firms not only generate a higher number of technological innovations (product and process) than service firms, they generate a higher number of organizational innovations.

Table 1: share of service and manufacturing firms introducing different types of innovations

Innovation activity	Percentage	
	Service firms	**Manufacturing firms**
Firms implementing one or more innovation mode(s)	54	63
Product innovation	20	35
Process innovation	29	38
Organizational innovation	40	43
Market innovation	27	22

b. Independent variables

Our goal is to measure the effect of cooperation on innovation output. Cooperation for innovation will therefore be our core independent variable. Cooperation is performed either between private actors forming "private-private INs" or between public and private actors forming "public-private INs". In private-private INs, innovative service firms cooperate with one or more of the following agents: other enterprises in their enterprise group, suppliers (equipment, materials, components or software), clients, competitors or other enterprises in their sector, and consultants, commercial labs, or private R&D institutes. Public-private INs for their part can be split into two modes. Firstly, "strict public-private INs", which relate to a private service firm cooperating with one or more public actors (universities or other higher education institutions and public organizations involved in R&D or private not-for-profit research institutes). The second, "extended public-private INs", describes a network where the private innovative service firm cooperates with one or more of the previous private actors as well as with one or more public actors. This extended public-private IN allows private firms to access not only the knowledge and technologies of public actors but also that of other private actors, where additional complementary resources are available and more innovation activities are feasible.

The fact that public actors in CIS4 are represented by universities or other higher education institutions and public organizations involved in R&D or private not-for-profit research institutes is one of limited in this study. These public actors are mainly producing complex or technological knowledge, but public actors might be main source of non-technological competences (tacit knowledge, skills, experiences, etc) like public administrations and public sectors like health and transportation sector.

Table 2 shows the share of firms cooperating for innovation by type of partner in French service and manufacturing firms. It shows that 29.67% of firms implement all types of innovation cooperation in services in comparison with 33.88% in manufacturing sector. Private cooperation is more important than public cooperation in service sector: only 1% of firms cooperate solely with public actors compared to 19.4% with private actors alone and 7.97% with both public and private actors (extended public-private INs). Also, there is higher percentage of manufacturing firms cooperating solely with private actors than service firms (19.4% vs. 18.33%), while the cooperation with public actors solely (1.49% vs. 1%) or with both public and private actors (14.07% vs. 7.79%) is higher than service firms.

The cooperation data in table 2 are also classified according to the geographical location of partners. Firms are involved in national cooperation (national innovation networks) if they cooperate with public or private partners in the same region or in other regions in France. They are involved in international cooperation (global innovation networks) if they cooperate with partners from Europe, the USA or other countries. Table 2 shows that national cooperation is the most frequent (25.12% cooperation with partners in France), and that on an international level, cooperation with European firms (11.75%) is the most frequent. This result is expectable knowing that the geographical proximity is likely to facilitate the building of social capital between partners and exchange of cognitive resources.

Table 2: Share of firms cooperating for innovation by type of partners

	Percentage of firms in service sectors						Percentage of firms in manufacturing sectors
Cooperation mode	**In General**	**In the same region**	**In other regions of France**	**Europe**	**USA**	**Other countries**	**In General**
Not cooperate at all	70.33	88.25	74.88	88.25	92.77	95.44	66.12
Cooperate with any actors	29.67	11.75	25.12	11.75	7.23	4.41	36.48
Enterprise in your enterprise group (a)	45.03	16.02	36.74	17.51	8.95	6.19	38.56
Supplier of equipment, materials, components or software (b)	57.85	13.54	50.61	16.69	9.17	5.08	54.13
Clients or customers (c)	44.03	14.81	36.13	14.81	7.13	6.85	47.86
Competitor or other enterprise in your sector (d)	35.47	7.68	21.16	9.56	4.14	3.59	33.23
Competitor in other group (e)	_____	5.91	16.85	6.96	2.54	2.43	_____
Consultants, commercial labs, or private R&D institutes (f)	29.05	7.46	25.69	8.34	3.70	2.38	38.41
Universities or other higher éducation institutions only (g)	23.81	**9.50**	19.06	7.46	3.48	2.71	36.32
Public R&D organization or private not-for- profit research institutes(h)	20.83	**6.74**	17.85	6.05	2.32	2.04	25.32
Cooperation with private actors only (a or b or c or d or e or f)	19.4	8.22	17.57	8.65	4.86	4.41	18.33
Cooperation with public actors only (h or g)	1	0.92	0.73	0.52	0.17	0.95	1.49
Cooperate with both public and private actors (a or b or c or d or e or f) and (h or g)	7.97	2.61	6.7	2.27	2.28	0.81	14.07
Number of observations	6076	6076	6076	6076	6076	6076	5510

(The figures in the table represent the percentage of cooperation for innovation between enterprises in France and other private or public actors either in the same region, country, or international actors in Europe and the USA).

In addition to innovation cooperation variables, the model includes a certain number of control variables: firm size, service subsectors and government subsidies (see Table3). Firm size is one of the key control variables, to the extent that innovation output may vary according to difference in size. For example, innovation activities other than R&D (which are supposed to be the main innovation activities in services) are widely performed by small and medium sized-units (see table 4). Large-sized firms are supposed to have more opportunities to benefit from economies of scale in both production and innovation (mainly R&D) (Cohen, 1996), therefore size is expected to have positive effect on innovation activities (Schumpeter, 1942). Most empirical studies reveal the positive effect of firm size. However, in some cases small firms might be more innovative than larger ones. In terms of cooperation, Fritsch and Lukas (2001) found that large firms are more likely to engage in cooperation (R&D cooperation). In contrast, Negassi (2004), in discussing the determinant of R&D cooperation, saw no significant difference between firms with small and large market shares with regards to cooperation. In this study, firm size is measured on the basis of the number of employees. A distinction has been made between thefollowing size categories: “small firms” (from 10 to 49 employees)[20], “medium firms” (from 50 to 250 employees), and “large firms” (more than 250 employees).

[20] Micro firms with fewer than 10 employees were dropped from the analysis.

Table 3: Descriptive analysis of control variables

Independent variable	**Percentage (%)**
Firm size	
Small firm $10 \leq$ employees < 50	41.06
Medium firms $50 \leq$ employees < 250	32.49
Large firms $250 \leq$ employees	26.45
Public subsidy for innovation activities	
Local or regional authorities	6.59
Central government (including central government agencies or ministries)	12.13
The European Union (EU)	5.94
Tax credits (including research tax credit)	10.28
Sectoral patterns	
Sale, retail, maintenance	5.46
Other wholesale trade	16.66
Other retail trade	10.16
Hotels & restaurants	4.97
Land transport	7.14
Water transport	0.48
Air transport	0.24
Supporting and auxiliary transport activities	4.90
Post and telecommunications	1.48
Financial intermediation	7.52
Real estate and renting	5.34
Computer and related activities	6.07
R&D	3.39
Other business activities	24.24
Other community, social and personal service activities	1.93

Table 4 shows that small service firms are more innovative than large and medium firms. If we look at the share of innovative firms in terms of firm size, we observe that small, medium and large firms realize similar proportions of product and process innovation, whereas small firms apply more organizational and market innovation compared with large and medium firms.

Table 4: Innovative firms in the service sector by firm size

Employee category	Service firms (2002-2004)				
	Innovation output	Product innovation	Process innovation	Organizational innovation	Market innovation
10-49	21.2	6.7	9.8	15.4	9.9
50-249	16.8	6.2	9.6	12.4	8.1
> 250	13.7	6.5	9	10.5	8.4

We included sectoral differences as another control variable. We build our study on the existence of sectoral differences between service industries regarding the amount of resources devoted to innovation (Evangelista and Savona, 2003), and the amount of innovation produced. For example, in France, there is heterogeneity between service subsectors regarding the intensity of R&D activities (see table 5) devoted to innovation. Service activities like R&D, computer, post and telecommunication perform high intramural R&D activities, but subsectors like sale, retail, maintenance and other retail trade (12.16%) perform low intramural R&D activities. Also, heterogeneity was noticeable between service subsectors regarding extramural R&D (but less than that for intramural R&D), for example 53% of R&D firms implement extramural R&D while this percentage declines to 3.44% for sale, retail and maintenance.

There is also heterogeneity between French service subsectors in relation to their sizes. Table 3 shows that other business services (24.24%) and other whole sale trade (16.66%) are the most frequent, while air transport and water transport have the smallest size with frequency of 0.24% and 0.48% respectively.

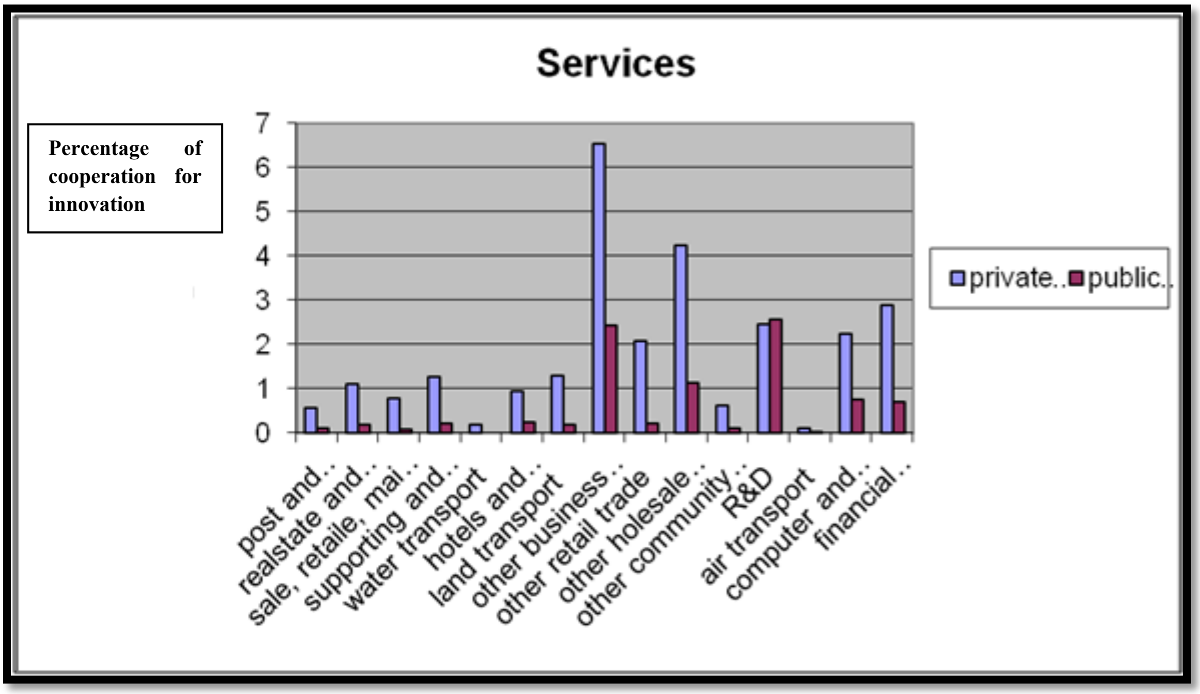
Table 5: Percentage of service subsectors that perform internal and external R&D

Service subsector	Intramural (in home) R&D (%)	Extramural R&D (%)
Sale, retail, maintenance	8.98	3.44
Otherwholesaletrade	22.55	9.86
Otherretailtrade	12.16	5.49
Hotels& restaurants	13.06	4.76
Land transport	13.40	6.01
Water transport	18.87	11.32
Air transport	29.17	4.17
Supporting and auxiliary transport activities	23.24	11.13
Post and telecommunications	42.22	12.59
Financial intermediation	37.56	11.60
Real estate and renting	18.20	5.90
Computer and relatedactivities	53.18	11.95
R&D	78.28	53.56
Other business activities	12.16	8.43
Othercommunity, social and personal service activities	26.07	6.41

In terms of INs trends, figure 1 shows the high heterogeneity between service subsectors in relation to the share of cooperation for innovation with public or private actors. In private cooperation, the cooperation proportion varies from 0.1% in air transport to 6.55% in other business activities. Public cooperation varies from 0% in water transport to 2.57% in the R&D subsector. Thus, cooperation with private actors is higher than the cooperation with public actors for most service subsectors. R&D

subsector highly cooperates with public actors due to the fact that public actors like universities and research centers present a main source of R&D.

Figure 1: Percentage of cooperation for innovation with public and private actors in different service subsectors in 2004



Public financial support (subsidies) for innovation is the last control variable. It is mainly provided by local and regional authorities, and central governments (national government and EU institutions). Public financial support is not the same as public cooperation. In public cooperation, public actors get involved in networks as main partners who share knowledge, technologies, and financial resources with private actors and also get involved in the network's other organizational and institutional activities. As regards public subsidy, private actors organize, monitor and control the innovation process, and the public actor is not involved directly in the project. They only provide some financial support without being involved in the exchange and creation of knowledge. We will compare these two modes of public action in order to assess which one is the more efficient to support innovation.

It should be noted (cf. table 3) that the central government is the main supporter for innovation activities in services (12.13%) compared with local or regional authorities

(6.59%) and the European Union (5.94%). This is due to the governance system in France which grants the central government the main role in public policy. Tax credit (including research tax credit) is also an important public policy for supporting innovation activities: it reaches 10.28%.

3. Empirical analysis results

In the following section we will present and discuss the results of our empirical investigation, i.e. the effect of cooperation on innovation output in French service industries. The estimation strategy is a compound of three models. In model one, we estimate the effect of cooperation on the four types of innovation output (product, process, organizational and market innovation). The result of model one may be used as a reference point for the other cooperation tests. In model two, we measure the innovation effects of cooperation for three different types of innovation networks: private cooperation (Private-Private INs), public cooperation (Strict public-private INs), and cooperation with both public and private actors (Extended public-private INs). In model three, we assess the effect on innovation of national vs. international cooperation i.e. of local vs. global network.

The model used to estimate our relationship is the binary election Logit model. It is run separately for every dependent variable (product, process, organizational and marketing). The alternative "innovate or not" is made possible for every dependent variable.

3.1. The effect of cooperation

Table 6 presents the results of cooperation for innovation regardless of partner types. The results do strongly support the positive impact of INs on innovation output, for all types of innovation (product, process, organizational and marketing innovation), i.e. the more cooperation, the more likely a firm is to introduce more innovation output. Although market and organizational innovation are more frequent than product innovation (see table 1), cooperation is more efficient for both product and process innovations (technological innovations). This can be explained by the fact that product and process innovations are technological innovations, which are based on complex scientific and technological knowledge and skills not always available within the firm and only found elsewhere. Conversely, market and organizational knowledge is more specific to the firm and idiosyncratic, which may reduce the need for external cooperation.

Table 6: Logit Estimation for impact of cooperation on the likelihood of introducing innovations relating to one or more types of innovations

	Product innovation		**Process innovation**		**Organizational innovation**		**Market innovation**	
Parameter	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq
Intercept	0.5298	0.0041	0.1574	0.2983	1.1185	<.0001	-0.0583	0.6428
Cooperation								
Cooperation	1.5838	<.0001	1.8456	<.0001	0.3038	<.0001	0.4566	<.0001
Observation number	6076		6076		6076		6076	
Wald	1144.4035		815.9124		100.1122		290.2511	
Percentage concordant	78.4		71.6		56.0		60.8	

*Significant at 0.10 level
**Significant at 0.05 level
***Significant at 0.01 level

For the control variables, we finds that firm size (SIZE1) has a strong and positive significant effect on the level of innovation output for all types of innovation output (product, process, organizational and market innovation), i.e. the relationship between innovation output and firm size is robust and consistent (see table 7). Innovative large firms have a higher effect on innovation output compared with medium and small firms. This means that large firms perform better than medium and small firms in all modes of innovation. However, in the case of market innovation, medium firms appear to have less effect compared with small ones. This result is consistent with what was mentioned earlier, i.e. that firm size is expected to have positive effect on innovation activities.

Table 7: Differences of innovation activities in relevant with firm size

Size (ref = 10 ≤ employees<50)	**Product innovation**		**Process innovation**		**Organizational innovation**		**Market innovation**	
Parameter	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq
50 ≤employees<250	-0.0570	0.1958	0.0559	0.1696	-0.0434	0.3127	-0.1308***	0.0006
250 ≤ employees	0.3100***	<.0001	0.3018***	<.0001	0.0908*	0.0556	0.3240***	<.0001

*Significant at 0.10 level
**Significant at 0.05 level
***Significant at 0.01 level

There are also (see table 8) significant differences between service subsectors as regards the level of innovation output whatever the types of innovation considered: product (ChiSq=272.22, P-value<0.0001), process (ChiSq=32.11, P-value=0.0039), organizational (ChiSq=56.6, P-value<0.0001) and market innovation (ChiSq=125.6, P-value<0.0001). The heterogeneity between service subsectors is higher for product and market innovation.

Taxonomy for service subsectors is also found which underlines the heterogeneity in the amount of innovation produced. For example, in regards with product innovation, three main groups are found. The first includes other retail trade, air transport, hotels, restaurant and financial intermediation which perform product innovation more than in R&D sector. The second includes real estate and renting, post and telecommunication, supporting and auxiliary transport activities and water transport with product innovation less than in R&D sector. Other wholesale trade, sale, retail, maintenance, land transport, other business activities and other community, social service activities with product innovation similar to that in R&D sector is the third group. In regards organizational innovation, two main groups are included in the taxonomy. The first comprises sale, retail and maintenance, supporting and auxiliary transport activities and post and telecommunication with organizational innovation less than in R&D services. The second includes other service subsectors which have organizational innovation similar to that in R&D services.

Table 8: Differences of innovation activities in relevant with service subsectors

Subsector (ref = R&D)	**Product innovation**		**Process innovation**		**Organizational innovation**		**Market innovation**	
Parameter	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq
Sale, retail, maintenance	**0.1797**	**0.3775**	**0.3660***	**0.0633**	**-0.7614*****	**<.0001**	**0.1017**	**0.5718**
Other whole sale trade	**-0.4847**	**0.4039**	**-0.0626**	**0.9130**	**1.3027**	**0.1790**	**0.9586**	**0.1191**
Other retail trade	**1.2620*****	**<.0001**	**0.1418**	**0.2530**	**0.1359**	**0.3413**	**-0.1117**	**0.3273**
Hotels & restaurants	**0.6518*****	**<.0001**	**0.1792**	**0.1296**	**0.1798**	**0.1978**	**0.3995*****	**0.0004**
Land transport	**-0.1683**	**0.2396**	**-0.0837**	**0.5213**	**-0.1595**	**0.2786**	**0.4115*****	**0.0012**
Water transport	**-0.2610****	**0.0384**	**-0.1939***	**0.0898**	**0.0921**	**0.4978**	**-0.7485*****	**<.0001**
Air transport	**0.2051****	**0.0137**	**0.0436**	**0.5870**	**0.00111**	**0.9912**	**-0.2414*****	**0.0017**
Supporting and auxiliary transport activities	**-0.8724*****	**<.0001**	**0.0649**	**0.5203**	**-0.5048*****	**<.0001**	**0.1447**	**0.1373**
Post and télécommunications	**-0.2451*****	**0.0091**	**0.0168**	**0.8485**	**-0.2046***	**0.0524**	**0.1782****	**0.0343**
Financial intermediation	**0.7312*****	**0.0021**	**-0.1370**	**0.5528**	**-0.2934**	**0.2041**	**0.1437**	**0.4931**
Real estate and renting	**-0.2873****	**0.0420**	**-0.1737**	**0.1748**	**0.2307**	**0.1345**	**0.1854**	**0.1284**
Computer and related activities	**-0.8094*****	**<.0001**	**-0.2451***	**0.0534**	**0.1563**	**0.2992**	**0.2406****	**0.0473**
Other business activities	**0.0718**	**0.6039**	**0.4084*****	**0.0026**	**-0.0256**	**0.8662**	**-0.4970*****	**<.0001**
Other community, social service activities	**0.0505**	**0.9012**	**0.2062**	**0.6194**	**0.0988**	**0.8214**	**-0.4755**	**0.1940**

*Significant at 0.10 level
**Significant at 0.05 level
***Significant at 0.01 level

3.2. Cooperation impact according to type of innovation network

Table 9 shows that public-private INs and private-private are both efficient strategies to produce innovation in services. This result shows that the non-linear (open) model of innovation constitute a sustainable way in accessing external knowledge and technological resources which are required in order to produce innovation in services in today's environment, i.e. it confirms the importance for service firms to shift from a linear to a non-linear model of innovation in which innovation is provided through complementarity between skills, competences, knowledge and technologies of more than one partner. It also demonstrates the synergies that public and private actors can mobilize through collaboration to produce innovation in services.

Both private-private INs and public-private INs are more efficient in producing technological innovation (product and process innovation) than non-technological innovation (organizational and market innovation), which is consistent with the results of section 4.1 i.e. that cooperation for innovation is more efficient to produce technological innovation. This can be explained by what we have mentioned earlier i.e. the fact that market and organizational knowledge is more specific to the firm and idiosyncratic, which may reduce the need for or the scope of external cooperation. Also, public actors in public-private INs are mainly represented by universities and public research centers that are major sources of complex knowledge which are mainly used to produce technological innovation.

The comparison between private-private INs and public-private INs as two cooperation strategies for innovation in service sectors demonstrate important results. Table 9, shows that in the case of product and process innovation, cooperation with public actors either through extended public-private INs or strict public-private INs has a positive and significant impact on innovation output. This result demonstrates the importance of public-private cooperation in the mobilization of cognitive resources needed to produce product innovation and supports the policies implemented by different OECD countries (OECD, 2005)[21], in order to strengthen links between science and service industries.

Public-private INs through the extended ones have a more significant effect on product innovation than private-private INs, despite the high percentage of firms which participate in private-private INs (19.4%) compared with those which participate in extended public-private INs (7.97%). Through extended public-private INs, firms are able to access a wide range of complementary cognitive, technological, financial, methodological and institutional resources. Private-private INs face some difficulties in providing the complex technological competences needed mainly for producing new product innovation in the services sector. Universities, research centers and R&D institutions are likely to be vital in providing such types of technological competences. This result contradicts the idea that a weak relationship exists between service firms and the public sector (OECD, 2005), and that the public sector is effectively the less important factor in terms of services innovation (Sundbo and Gallouj, 1998).

Private-private INs appears to be more efficient than public-private INs for achieving process innovation. Through cooperation with private partners only (e.g. other enterprise and rival firms), therefore, firms are more likely to access relevant competencies and technologies required for improving production processes, new distribution methods and support activities.

Table 9 shows that service firms also cooperateto access non-complex knowledge (organizational and market innovations), which contradicts the opinion of Charles Edquist (1997) that a network-based analysis is assigned mainly to obtain new technological innovations. Cooperation in private-private INs or extended public-private INs is important in realizing both organizational and market innovation.

[21] This report mentions several successful examples of cooperation between service firms and public science actors (research centers and universities), for example, in New Zealand and in the Czech Republic.

Public-private INs represented by the extended networks have the most significant effect on both organizational and market innovation. Although they relate to non-technological innovation, organizational and market innovation may be heavily reliant on technologies (computing and telecommunication technologies), which means a need for R&D-based, complex and diverse knowledge that universities, public and private research centers provide.

Table 9: Logit model for private and public cooperation in service firms

	Product innovation		**Process innovation**		**Organizational innovation**		**Market innovation**	
Parameter	**Estimate**	**Pr > ChiSq**	**Estimate**	**Pr > ChiSq**	**Estimate**	**Pr > ChiSq**	**Estimate**	**Pr > ChiSq**
Intercept	0.4804	0.0111	0.3285	0.0332	1.0371	<.0001	-0.1259	0.3399
Cooperation								
privatecoop_o	1.5400***	<.0001	2.0401***	<.0001	0.2518***	0.0016	0.4250***	<.0001
Publiccoop_o	1.1241***	0.0004	1.1909***	0.0001	-0.1269	0.6605	-0.3088	0.2888
Mixtecoop	1.8554***	<.0001	1.3374***	<.0001	0.5923***	<.0001	0.6961***	<.0001
Observation number	6076		6076		6076		6076	
Wald	1138.3107		815.9045		107.2148		300.2394	
Percentage concordant	78.4		71.4		56.1		61.1	

*Significant at 0.10 level
**Significant at 0.05 level
***Significant at 0.01 level

3.3. Public cooperation and public subsidy

In table 10, public subsidies from local, regional or national organizations and tax credits have a positive significant effect on both product and process innovation. In contrast, public subsidies have no effect on market innovation and a negative effect on organizational innovation. This could mean that governments more rarely subsidize firms' innovative activities related to the structure and management of the organization and sales methods.

A comparison between table 9 and 10 shows that the direct involvement of public actors as key partners who cooperate with other private actors forming public-private innovation networks is more efficient for firms in terms of boosting innovation output over public subsidies (indirect involvement in innovation processes). In other words, cooperation with public actors through the strict and extended public-private INs is more efficient for product, process, organizational and market innovation than public subsidies. Governments, through direct cooperation, can provide their own specific knowledge, and control the process of information and technology flow between different actors more efficiently, and more generally can ensure that public technological and financial capabilities are correctly employed in the development of the innovation.

Table 10: The effect of public subsidy on the probability to have innovation output

Public subsidy	**Product innovation**		**Process innovation**		**Organizational innovation**		**Market innovation**	
Parameter	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq
FunLoc	0.2658***	0.0075	0.3694***	0.0002	0.1819**	0.0490	0.1131	0.1473
FunGmt	0.4432***	<.0001	0.1416*	0.0544	-0.1507**	0.0298	-0.1709***	0.0069
FunEU	-0.1353	0.3237	0.2026	0.1964	0.0206	0.8783	0.0441	0.6997
FunRtd	0.2339	0.2365	-0.3307*	0.0792	-0.00033	0.9984	-0.1651	0.2455
CIR	0.8405***	<.0001	0.1951***	0.0056	-0.1036	0.1198	0.0368	0.5406

*Significant at 0.10 level
**Significant at 0.05 level
***Significant at 0.01 level

3.4. Cooperation impact according to type of public partner

One of the main goals of this study is to examine the role of public actors in public-private INs. We will therefore now focus on two different types of public actors (universities and higher education institutions, on the one hand and public organizations involved in R&D and private not-for-profit research institutes, on the other hand) in order to reveal the effect of the participation of each type of actor on innovation output. In table 11, it is clear that both public actors have a positive and highly significant impact on the probability of producing both product and process innovations. But universities and higher education institutions are a little more efficient than R&D organizations in terms of both product and process innovation.

The positive impact of the two types of public sectors may be based on the fact that product and process innovations are technological innovations and therefore need complex knowledge and technologies that universities and R&D organizations can efficiently provide. However, universities in France are more efficient in providing these technologies than R&D organizations, because of the wider range of knowledge (beyond S&T) provided by universities compared to more specialized R&D organizations.

Cooperation with universities has a significant and highly positive impact on organizational and market innovation. This is not the case for cooperation with R&D organizations and private not-for-profit research institutes. Market and organizational innovations are non-technological innovations based on non-S&T knowledge available in Universities.

Table 11: Logit estimation for innovation cooperation equation with private and the two main public partners

	Product innovation		Process innovation		Organizational innovation		Market innovation	
Parameter	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq
Intercept	0.5994	0.0022	0.5843	0.0003	0.7132	<.0001	-0.2397	0.0772
Cooperation								
Privatecoop	1.2590***	<.0001	1.8092***	<.0001	0.1712**	0.0348	0.3544***	<.0001
coop_univ	1.4258***	<.0001	1.0290***	<.0001	0.6401***	0.0042	0.6144***	0.0004
coop_RD	1.3493***	<.0001	1.0054***	<.0001	-0.0298	0.8955	-0.0735	0.7149
Observation number	6076		6076		6076		6076	
Wald	329		167.5		973.6		1250.5	
Percentage concordant	63.1		60.1		76.4		81.8	

*Significant at 0.10 level.
**Significant at 0.05 level.
***Significant at 0.01 level

3.5. National and international cooperation

In this section, we examine the differences that exist in terms of innovation outcome between national (local) and international (global) cooperation. The analysis, once again, is based on a comparison between public-private INs (both extended and strict) and private-private INs.

Local public-private INs represented by the extended ones are the most efficient cooperation strategies in terms of boosting product innovation (see table 12). This result is plausible to the extent that service firms may need both private and public competences, mainly at national level, because most products are directed at the local market. The significant positive effect of global private-private INs on boosting product innovation may result from the need for French firms to adapt to local markets in other EU countries. For example, they cooperate with clients and suppliers in order to access more market information. The high percentage of firms cooperating with suppliers and clients from EU countries (see table 2) is consistent with this result.

Regarding the process innovation, national INs – as for product innovation –are more efficient than international INs. National private-private INs, national strict public-private INs and national extensive public-private INs have a significant positive effect on the probability of producing process innovation (see table 12). However, local private-private INs are more efficient than the other two types of networks. This is consistent with the result we discussed in section 4.2 that cooperation only with private actors is more efficient than other cooperation modes, i.e. in the case of process innovation.

For organizational and market innovation, global cooperation relating to the three types of cooperation (private only, public only, and both public and private) has no significant effect (see table 12). This result is consistent with the fact that organizational and market innovations are not technologically intensive. There is therefore less need for international cooperation, and local public and private actors are able to provide the technological competences (mainly ICTs) and more localized non-technological knowledge that may be needed for both market and organizational innovation.

Table 12: Logit model for National and International cooperation

Parameter	Product innovation		Process innovation		Organizational innovation		Market innovation	
	Estimate	Pr>ChiSq	Estimate	Pr>ChiSq	Estimate	Pr>ChiSq	Estimate	ChiSq
Intercept	1.2748	<.0001	0.9600	<.0001	1.2599	<.0001	0.1870	0.1190
Cooperation								
privatecoop_nat_o	1.0863***	<.0001	2.0223***	<.0001	0.2012**	0.0286	0.2658***	0.0008
publiccoop_nat_o	0.5061	0.1977	0.9583**	0.0169	-0.4559	0.1982	-1.0503**	0.0105
privatecoop_int_o	1.4437***	<.0001	1.0462***	<.0001	-0.1276	0.6143	-0.0246	0.9163
publiccoop_int_o	-12.6400	0.9644	9.6131	0.9537	9.6416	0.9605	-9.3590	0.9546
mixte_nat	1.6559***	<.0001	1.3376***	<.0001	0.4055*	0.0505	0.4626***	0.0067
mixte_int	1.8666	0.1554	1.3117	0.2560	0.3822	0.7350	-1.1060	0.3251
Observation number	6076		6076		6076		6076	
Wald	266.12		94.09		667.8		942.15	
Concordant percentage	60.3		56		70		76	

*Significant at 0.10 level
**Significant at 0.05 level
***Significant at 0.01 level

4. The cooperation effect on innovation in the services and manufacturing sectors

As we have mentioned previously, most of the theoretical and empirical literature about cooperation for new technologies (mainly R&D cooperation) and innovation networks is focused on the manufacturing sector, ignoring innovation networks in the services sector.

Before comparing the cooperation effect on innovation in manufacturing firms and in the services sector, we will compare their propensity to cooperate. The share of firms cooperating for innovation in manufacturing (regardless of the mode of cooperation or with whom they cooperate) is larger than services (36.48% vs. 29.67%). This result is explained by the high cooperation ratio with public actors (universities or other higher education institutions and public organizations involved in R&D or private not-for-profit research institutes) and with consultants, commercial labs, or private R&D institutes in the manufacturing compared with that in service sector (see table 2). This can be explained by the fact that these actors are more specialized in the production of R&D activities and complex technologies that are considered more crucial for innovation activities in manufacturing. This also supports the idea of the importance of public-private INs not only in services but also in manufacturing sectors. The cooperation with private actors in service sector is a little more than that in manufacturing sector (19.4% vs. 18.33%). This is not unexpected as the interaction between producers, suppliers of raw materials, clients and competitor firms is important in the production of service output.

Table 13 shows that in the manufacturing sector, the cooperation strategy is efficient for all types of innovation. However the probability of producing product and process innovation through cooperation is higher than that of producing organizational and market innovation. This may be explained by the fact that product and process innovation in manufacturing is technologically intensive and needs a greater complex knowledge than for organizational and market innovations, although manufacturing firms might not be able to produce them based on their internal capabilities; they therefore cooperate with external elements to obtain new knowledge and technologies. This is consistent with Tether (2002), since the conduct and intensity of R&D activities have a significant impact on firms willing to cooperate; firms which introduce goods that are new to the market (new product innovations) are more likely to cooperate to develop them.

Table 13: Logit model for the innovation effect of cooperation for innovation in manufacturing firms

	Product innovation		**Process innovation**		**Organizational innovation**		**Market innovation**	
Parameter	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq
Intercept	0.3392	0.0418	0.8893	<.0001	1.0913	<.0001	-1.1571	0.9146
Cooperation								
Cooperation	1.4086***	<.0001	1.1410***	<.0001	0.3174***	<.0001	0.2031***	0.0038
Observation number	5510		5510		5510		5510	
Wald	850.9836		495.2117		169.4266		312.1762	
Concordant percentage	78.2		70.8		61.2		64.9	

*Significant at 0.10 level
**Significant at 0.05 level
***Significant at 0.01 level

The inter-sectoral comparison of cooperation influences on innovation output reveals an unexpected result. Cooperation strategy in the service sector is more efficient than in the manufacturing sector for producing product, process and market innovations, while there is no significant difference as regards organizational innovation (see tables 6 and 13). This could be explained by the fact that manufacturing firms have higher internal abilities (in-house R&D and the acquisition of machinery and equipment) than the services sector in producing the knowledge and technologies needed for producing new innovation output. Therefore, service firms are more likely to rely heavily on the acquisition of knowledge and technologies from outside to generate their innovation output, mainly relating to product and process innovation (see table 9). Moreover, in the services sector the role of private partners (consultants, consumers and suppliers) turns out to be more efficient in producing new innovation output than in the manufacturing sector.

As regards the type of INs (private-private INs, public-private INs) and their consequences on innovation performance, the result is similar to that in the services sector. Public-private INs represented by the extended one are the most efficient strategy for producing product innovation, while using either private-private INs or extended public-private INs have nearly the same influence on process innovation. This result is based on the fact that innovation in manufacturing is highly dependent on complex knowledge and technologies; public competences from universities and R&D institutions are supposed to be vital resources for new knowledge and technologies required for producing new product and process innovation. Consequently, complex technologies from universities and R&D activities are not the most crucial resources for efficient product and process innovation; rather they should be accompanied with knowledge and information from private actors to create maximum effect.

Public-private INs represented by the extended ones are the most efficient strategies for boosting both organizational and market innovation. The same discussion on the efficiency of extended public-private INs for both organizational and market innovation in the services sector is likely to explain the efficiency of extended public-private INs in the manufacturing sector. Both knowledge and technological competences from public and private actors are crucial for generating organizational and market innovation. Firms need to cooperate with clients and producers to access market information, and with competitors to solve common organizational managerial problems (problems outside the realm of competition). They also need to organize common relations with other public institutions and NGOs (like syndicate semi-public institutions) and with universities and public research centers to adapt to new complex technologies associated with the use of ICTs in relation to new organizational changes, new sales channels (such as internet sales) and new media or techniques to generate new products.

The inter-sectoral comparison of INs influences on innovation output shows that public-private INs either through strict or extended are more efficient in the service than in the manufacturing sector for producing product, process and market innovations (see tables 9 and 14). Extended public-private INs are a little more efficient in manufacturing sector for producing organizational innovation. These results should be reflected in the design of the public policies. To prompt innovation in services, it is important for the public institutions to re-direct the public policies which mainly focus on prompting traditional INs in manufacturing sector, and adopt new policies and regulations in support of public-private INs in services through the stimulation of public service sectors to engage in cooperation relationships with private actors (policies to increase the number of public-private INs in services). These policies are important to go beyond the scientific and technological policies favoured in manufacturing sector. In other words, the public policies may consider the fact that innovation in services includes both technological and non-technological innovation. Thus policies for supporting cooperation for non-complex technologies (knowledge, skills, non-technological competences, new approaches, etc) should be encouraged.

Table14: Logit model for private and public cooperation in manufacturing firms

	Product innovation		**Process innovation**		**Organizational innovation**		**Market innovation**	
Parameter	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq
Intercept	0.3068	0.0722	0.8880	<.0001	0.9798	<.0001	-1.2218	0.9092
Cooperation								
Privatecoop_o	1.3958***	<.0001	1.1556***	<.0001	0.1486*	0.0693	0.1201	0.1429
Publiccoop_o	0.9080***	0.0025	0.8857***	0.0018	0.3501	0.1739	-0.0452	0.8567
Mixtecoop	1.5195***	<.0001	1.1480***	<.0001	0.6586***	<.0001	0.3835***	0.0001
Observation number	5510		5510		5510		5510	
Wald	847.9670		495.7822		183.1952		318.2012	
Concordant percentage	78.3		70.8		61.7		65.0	

*Significant at 0.10 level
**Significant at 0.05 level
***Significant at 0.01 level

Also significant differences between service and manufacturing in relation to level of innovation output whatever the types of innovation considered is noted: product (ChiSq=287.65, P-value<0.0001), process (ChiSq=15.7, P-value<0.0001), organizational (ChiSq=77.79, P-value<0.0001) and market innovation (ChiSq=258.9, P-value<0.0001). In services, the comparison of the inter-sectoral differences with the intra-sectoral differences in section 4.1 shows that intra-sector heterogeneity is weaker than inter-sector heterogeneity in terms of product, organisational and market innovation, while intra-sector is stronger than inter-sectoral for process innovation.

Conclusion

This study highlights the effect of INs on innovation performance in French innovative service firms, considering different types of cooperation strategies. Service firms can cooperate solely with private actors to form private-private INs, solely with public actors to form strict public-private INs or with both public and private actors to form extended public-private INs. In addition, these entities can cooperate with local, national or international partners, and constitute national innovation networks or global innovation networks.

Innovation networking and cooperation is not only important for manufacturing firms involved in high tech activities and intensive R&D cooperation. It is also important for service firms which cooperate to enhance both technological and non-technological innovation.

Our estimations show that all types of innovation are positively affected by cooperation (one or more of the three innovation networks). However, the different innovation types are not equally affected by the private-private INs and public-private INs. In other words, the efficiency of cooperation strategies may vary according to the type of innovation output. For example, extended public-private INs appear to be more efficient for product innovation, and private-private INs seem to be the most efficient strategy in the case of process innovation.

One of the most unexpected results is thatcooperation strategies in the services sector appear to be more efficient than in the manufacturing sector for most modes of innovation (product, process and market innovation). As such, public-private INs in the services sector are likely to be used in order to reduce the innovation gap that characterizes modern service economies.

The geographical location (national or international) of cooperation partners also has various effects on innovation output. Local cooperation is the most significant strategy for all types of innovation output: local private-private INs in terms of process innovation and local extended public-private INs in terms of product, organizational and market innovation. The significance of global private-private INs in terms of product and process innovation is mainly associated with the desire of French service firms to access the international market, mainly in the EU region.

Finally, as regards public policies to support innovation, our analysis shows that the direct involvement of public actors in public-private INs is more efficient than public subsidies (indirect involvement in the innovation process). Accordingly, public-private INs can be considered as important tools of public policy.

Conclusion of part 3

In this part we have provided two empirical works about the important role of public-private innovation networks in service sectors (ServPPINs) in the mobilization of new cognitive resources between public and private sectors, and in the production and diffusion of innovation output in services. The first empirical application in chapter 5 has shown how the innovation processes are concretely implemented under the conceptual framework of real ServPPINs (Lyonbiopole), which was developed in chapter 4 to describe the production ofcomplex innovation. It has also shown how the SNA is important to explain the interactions between public and private actors through the 3 years life cycle of Lyonbiopole, and to determine their roles in the innovation process. The cooperation with international actors was found to be determinant for the innovation process in Lyonbiopole.

Chapter 6 was another empirical illustration of the ServPPINs discussed in Chapter 4. Using real data from French CIS4, it was shown that implementing INs associating public and private organizations is an efficient strategy for the enhancement of innovation in services. It has also complemented the empirical discussion carried out in chapter 2, showing that the useof INs strategy in services is likely to enhance innovation outputs and consequently to lead to positive effect on economic performance.

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General conclusion

The concept of innovation network has mainly been applied to account for innovation cooperation in the manufacturing sector. This important concept has rarely been applied to services. This underestimation of INs in services is linked to the underestimation of innovation in services and to the predominance of assimilation approaches which consider service sectors as non-innovative or only as adopters of technological innovation developed in the manufacturing sector.

In this work, we have shown that INs, especially when they combine public and private service actors, are both a very important theoretical concept and a rising economic reality in service sectors as well. However, to support such a conclusion a more general concept of innovation is necessary. This concept of innovation is broad and open in the Schumpeterian tradition, i.e. it combines both technological and non technological dimensions of innovation.

This broad concept of innovation has been extensively discussed in the first part of this work, both from a theoretical and literature survey perspective and from an empirical perspective.

The first chapter consisted of a survey of the literature on innovation in services using the assimilation-differentiation-integration framework. The integrative perspective (seeking to provide the same analytical framework for both goods and services and for technological and non-technological innovation) has been confirmed as the most satisfactory perspective to address innovation in postindustrial and knowledge economies.

In the second chapter, we applied such an integrative perspective to compare innovation activities and the relationship between innovation and economic growth in manufacturing and services, using the French CIS4. We found significant differences in innovation behaviors in services compared to manufacturing as regards several indicators. For example, the manufacturing sector is more dependent than the service sector on public sources of information. It implements more intramural and extramural R&D activities. Another important result of this chapter is the positive effect of innovation in services on economic performance mainly when technological and non-technological innovation activities are applied simultaneously. This result is consistent with the hypothesis that the economic performance of innovation in services is the result of the synthesis of technological and service-based innovation strategies.

In the second part of this work, we have introduced a theoretical discussion of the concept of innovation networks in service sectors and of the importance of the cooperation between public and private service sectors.

The cooperation between public and private sectors is not new, as far as it was already at the heart of the development of PPPs which rose because of the deficiency of public actors to provide their services depending only on their own resources. While the PPPs focus on the economic objective of cooperation (access for new financial resources, transfer the risks to the private actors, make new profits, etc.), in PPINs public and private actors cooperate to mobilize cognitive resources (knowledge and technological resources, information, skills, know-how) which are required to the production of innovation output.

INs and PPINs have been highly discussed in the manufacturing sector. They describe public and private actors cooperating to mobilize complex knowledge and technology which is employed to produce new technological innovation. Public actors involved are mainly universities and public R&D institutions, which are the main sources of complex knowledge.

Our analysis of TechPPINs is based on the four following elements: 1) the inclusion of public and private actors; 2) the dynamic process of interactions between network actors; 3) the existence of social relationships; 4) a network life cycle growth model. These are the main components of a conceptual framework involving a coordination mechanism which provides coherence between the public-private "socio-cognitive" interactions along the network life cycle growth model in order to produce technological innovation. We combine SNA and networks life cycle to describe the development of innovation processes in the three life cycle stages.

Chapter 4 focuses on the PPINs in service sectors. The TechPPIN concept suffers from two important biases: technological and sectoral. TechPPINS are formed to produce and diffuse technological innovation in manufacturing sector, and they do not account for the non-technological nature of innovation when public and private services are the main actors in the network. Therefore, the new ServPPIN concept supposed is a network which mobilizes the complementary cognitive resources of public and private actors in order to produce (technological and non-technological) innovation in services.

We have developed a conceptual framework which describes the innovation process in ServPPINs. This conceptual framework includes the main constituent elements of the TechPPINs, but with major differences in the public and private actors involved, the cognitive resources mobilized and the measures of SNA.

To explain the innovation process in ServPPINs and the different innovation types that may be produced, the coordination mechanism in ServPPINs conceptual framework consists of two main processes. The first represents the synthesis between the constituent elements. The second describes the "adaptation mechanism" in the conceptual framework. This adaptation mechanism is important to consider the differences in the ServPPINs and their associated innovation output i.e. to take into account the taxonomy of ServPPINs developed by Djellal and Gallouj (2010c).

In this conceptual framework, the innovation mechanism is different in the four ServPPINs (ServPPINs for adopting technological innovation, ServPPINs for producing technological innovation, ServPPINs for producing non-technological innovation and ServPPINs for producing architectural innovation). This is expressed through the differences in the nature of participants' public and private actors and their associated role, and through the differences in SNA through the three stages of network life cycle model.

The third part of this work was devoted to the empirical illustration of our theoretical ServPPIN framework.

Chapter 5 provided a ServPPIN case study (Lyonbiopole) using the conceptual framework. Lyonbiopole is a ServPPIN built in the health sector to produce complex innovation through the mobilization of complementary cognitive resources of public and private actors in a dynamic and a social process along a three years life cycle model. The innovation mechanism of "complex or architectural innovation" ServPPINs is applied to describe the innovation process under the conceptual framework.

In this case study, the public actors (e.g. CNRS, Inserm and university of Lyon 1) had key roles in the crystallization stage of Lyonbiopole. This is consistent with the network life cycle growth model in the first stage. In spite of increasing the importance of private actors in the commercialization and consolidation stages, the public actors keep the control power also in these two stages. Lyonbiopole formation of small-world network is also an important factor in the production of innovation. It provides the network with high amount of social capital and efficient exchange of knowledge and technology.

In chapter 6 using French CIS 4, we have provided an empirical test of the effect of cooperation between public and private sectors (ServPPINs) on innovation output. The INs strategy is not only successful to provide technological innovation in manufacturing sector, but it is also important to mobilize the cognitive resources which are used to produce innovation output in service sectors. We also found that the PPINs are more efficient in the service sector than in the manufacturing sector.

A comparison has also been made between innovation networks with homogeneous actors (i.e. private actors only) and with heterogeneous actors (i.e. public and private actors). We found that, in services, the public-private INs are more efficient in term of innovation output than private-private INs.

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