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INNOVATION AND ECONOMIC PERFORMANCE OF THE FIRMS IN THE SERVICE SECTOR: RELEVANT ISSUES AND OPEN PROBLEMS

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I. Introduction: Why we study innovation in the service sector?

The present work is a collection of essays related to the topic of innovation in the service sector. This issue is very broad and very important.

It's broad because there's no such a thing as "the" service sector. The sector itself was born as a residual category in the national account system, like the result of "putting together" all those activities not classifiable as agricultural or manufacturing.

So treating the issue of innovation in the service sector means actually spotting the main problems that some common features of all services, especially of service output, create when we attempt to study innovation in the service sectors. More precisely, we will deal with definition questions; measurement problems; and issues regarding the application of the productivity concept in the service sector.

It's also an important topic due to tertiarisation transformation of the economy - the secular movement in the productive structure from agricultural to manufacturing first and then form manufacturing to service. This process, that is a matter of debate among scholar, is nonetheless a real process with whom we have to cope in some ways.

Studying the innovation dynamics in a broad sector that has become in the last decades the dominant sector in advance economies in terms of employment and GDP is a question of crucial importance that cannot be delayed anymore.

And, as a matter of fact, has not been avoided: this work rest on a growing literature studying innovation in the service sectors form different angles and in different context.

The choice of structuring this thesis as a collection of essays is functional to the purpose of single out some of the relevant issues and try to tackle them, revising first the state of the literature and then proposing a way forward.

Three relevant issues has been therefore selected: (i) the definition of innovation in the service sector and the connected question of measurement of innovation; (ii) the issue of productivity in services; (iii) the classification of innovative firms in the service sector.

Facing the first issue, chapter II shows how the initial width of the original Schumpeterian definition of innovation has been narrowed through time and then passed to the service sector form the manufacturing one in a reduce technological form.

Then it reviews the three traditional approaches to the study of innovation in the service sector and the actual instrument to measure it. Finally, a description of one of the main survey used to collect data on innovation at EU level - the Community Innovation Survey (CIS) – is provided, highlighting especially the shortcomings (in general and when it comes to its use for service's analysis) and pointing possible future directions for improvement.

Chapter III tackle the issue of productivity in services, discussing the difficulties for measuring productivity in a context where the output is often immaterial. Then we reconstruct the debate on the Baumol's cost disease argument, which has long affected the way in which we look at productivity in the service sector. Than we discuss the positions of those who argue that the concept of productivity has no sense in a context like the service sector and has to be substituted by some new multidimensional measure of performance. Finally, we propose two different ways to advance the debate on the topic of productivity in services; form one hand redefine the output along the line of a characteristic approach; and form the other redefine the inputs, particularly defining which kind of input it's worth saving.

Chapter IV is an empirical contribution that tries to derive an integrated taxonomy of innovative service and manufacturing firms, using data coming from the 2008 CIS survey for Italy. This taxonomy is based on the enlarged definition of "innovative firm" deriving from the Schumpeterian definition of innovation and classify firms using a cluster analysis techniques. The result is the emergence of a four cluster solution, where firms are differentiated by the breadth of the innovation activities in which they are involved. The results are interesting but need to be corroborate with most in depth researches on other aspect of the innovation process, such as the innovative inputs, that are collected already today but only for firms performing technological innovation.

Chapter 5 reports some of the main conclusions of each singular previous chapter and the points worth of further research in the future.

II. The concept of "innovation" in the service sector: definition's problems and measurement issues

1) Introduction

Innovation has for a long time been a neglected topic in economic literature. In classical and neoclassical representation of the production process (the typical Cobb-Douglas production function) there is no space for innovation. Output is a function of the inputs used in the production process (typically labour and capital) and innovation is something that occurs – if occurs – somewhere "outside" of the system. This is the famous vision of innovation as "manna from heaven" (Freeman, 1994, pg 463). The realization that a huge part of the growth in output was not explainable by the growth of inputs – the so-called Solow residual (Solow, 1957) – led to the elaboration of new models of growth (the endogenous growth models) and to a new attention to the phenomenon of innovation, conceived initially as only technical change.

This narrow neoclassical vision of innovation as technical change is still dominant in the economic field and has strongly conditioned the studies on innovation. The fact that innovation is mainly conceived as technical change has restricted its analysis to the sector where this technical change is more common and/or more evident: the manufacturing sector.

So, innovation in the service sector has been ignored until recently as the result of a two concurring evolutions of the theory: innovation as an external characteristic of the economic system from one side; and innovation as technical change, once it has been included, from the other.

The increasing importance of the service sector in modern economies, coupled with the acknowledgment that innovation is not only technical change and not only confined in the manufacturing sector, has generated a new strand of literature dealing with innovation in the service sector. Three are the main approaches in which the issue of service innovation has been treated: assimilation, differentiation and integration approach (Gallouj and Savona, 2009).

This paper reviews the literature on service innovation, focusing on how we conceive and measure innovation in the service sector and how this has been affected by the so-called "manufacturing bias". With "manufacturing bias" – the clue is in the name – we mean the distortion created by the exclusive focus of the first waves of innovation studies on firms in the manufacturing sector. The question that we address here is: to what extent has manufacturing bias has influenced our definition of innovation in the service sector and the way in which we structure our instrument to detect the innovative efforts of service firms? In particular, we study in detail the main survey on innovation carried out at European Union level: the CIS survey. We try to evaluate how much the CIS survey is an appropriate instrument for detecting innovation in the service sector and to assess if it is possible to forgive its original sin of being conceived as a manufacturing survey.

To deal with those questions, the paper is structured as follow: section two deals with the definition of innovation when it comes to services; section three reviews the three different approaches to the study of innovation in the service sector; while section four tackles the measurement problems specific to service innovation and the different kind of surveys used to detect it; in section five the CIS survey is looked at in detail, underlying in particular its shortcomings for empirical analysis focusing on the service sector; section six concludes.

2) How we conceive innovation in the service sector?

A clear understanding of what we mean when we talk about innovation is the precondition of any attempt to study innovation itself, either if we are concerned about how it occurs, of if we want to know what its effects are on growth and employment.

Despite the fact that innovation is "as old as mankind itself" (Fagerberg, 2005, pg 1), its systematic study is a relatively recent phenomenon. The emerging field of "economics of innovation" has first concentrated its attention on the innovation in the manufacturing sector, leaving aside the service one, creating a kind of "manufacturing bias". This attitude towards the service sector is an old and common feature of economic studies. The service sector has traditionally been seen as a residual one, including “a miscellaneous collection of industries that clearly are not in agriculture, mining, or manufacturing” (Fuchs, 1968, pg 16).

Once the role of the service sector in the economy – in terms of share of GDP and employment – has grown up to a point that it couldn’t be ignored anymore, also the innovation studies have started to give some attention to the long neglected topic of “innovation in the service sector”. But they have looked at it mostly through lenses distorted by the manufacturing bias, creating a series of ambiguities and misunderstandings. According to Coombs and Miles :

“For a surprisingly long time, economists and sociologist largely neglected this growing significance of services. Much of the theory, and many of the statistical instrument, which we use to chart socio-economic change and to develop and assess policy measures, remain based on approaches developed to deal with a world in which manufacturing occupied a predominant role. Nowhere is this truer than in the field of innovation studies” (2000, pg 86.)

In this section we will consider separately two distinct aspects that has been influenced by the manufacturing way of studying innovation: its definition and the analysis of how it occurs.

2.1) The definition of innovation: how Schumpeter’s legacy has been treated

Mainstream economic theory has long ignored innovation, regarding it as a phenomenon happening outside the economic system - the notorious imagine of innovation as “manna from heaven” (Freeman, 1994, pg 463). This doesn’t mean that innovation was an unexamined subject by economists. Among the many legacies of Schumpeter’s work there is also a broad and all-comprehensive definition of what innovation is. In one of his main works, Schumpeter (1934) defines innovation as:

“ the introduction of a new good […] of a new method of production […] the opening of a new market […] the conquest of a new source of supply of raw materials […] the carrying out of a new organization” (1934, pg 66).

When an explanation of the so-called "Solow residual" (Solow, 1957) observed in the manufacturing sector was needed, mainstream economics could not keep ignoring innovation. Faced with the urgency of actually studying innovation, it went back in a way to Schumpeter's definition. But instead of embracing the original concept in all the depth and breadth of the first formulation, the focus was narrowed to "the introduction of new good or new methods of production". Innovation is the successful commercialization of an invention that becomes a new product or process. It can be radical or incremental and affects the production function [1] of a firm, allowing to produce more output with the same amount of input or the same amount of output using less input[2].

This way of conceiving innovation as something that has a technical dimension (being it a new product or process) has been dominant in the early phase of innovation studies. Some of the interesting elements of the broader Schumpeter's definition – like the inclusion of the organizational or the market dimensions – have been initially left out of the picture.

The restriction of the definition of "innovation" to its technical dimension has created a kind of overlapping between the concept of innovation and the notion of technical change, which are used almost synonymously. This way of conceiving innovation lead to missing other important aspects of the phenomenon spotted by Schumpeter's original definition, hampering our understanding of it. The choice of focusing only on product and process innovation created a technological bias in innovation studies that has since then affected our analysis of innovation.

The technological bias was soon coupled and merged with another bias that emerged almost at the same time: the so-called "manufacturing bias" - the distortion created by the exclusive focus of the first waves of innovation studies on firms in the manufacturing sector. This early attention has acted as a sort of imprinting on the field

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1 As for instance Oscar Lange puts it : "Innovations are such changes in production functions, i.e., in the schedules indicating the relation between the input of factors of production and the output of products, which make it possible for the firm to increase the discounted value of the maximum effective profit obtainable under given market conditions" (1943, pg 21). Lange's definition is an example of the general mainstream approach to innovation, focusing on its effect on the production function and based on the assumption that its definition is restricted to the new product or new process part.

2 For a distinction between invention and innovation, product and process innovation, radical and incremental innovation see, for example, Fagerberg (2005, pp 4-9).

of innovation studies, and strongly influenced the conceptual instruments designed to detect innovation and the empirical analysis carried out in the field. In a way, the initial narrow definition of innovation adopted and the exclusive focus on the manufacturing sector were two faces of the same coin. The early focus on manufacturing sector was justified by the importance of the sector in the economic structure of developed countries in the Fordist. Also, the characteristics of the sector itself matter, given that it has a clearly identifiable output and is suitable for analysis focused on new product and new process of production[3].

So, technological and manufacturing biased together[4], combined with the "residual" role of the service sector, prevent a more careful evaluation of service firms' innovation activities in the long term. Moreover, when innovation studies first tried to look at these activities, they found very few innovations (in a technical strict sense), conducing to the development of an "haircut view" of service sector (Miozzo and Soete, 2001, pg 159)[5]

The importance this sector has acquired in modern economies in terms of GDP and employment (see, for example Wölfl, 2006) has pushed researchers to have a closer look at the service sector in search of innovation activities that could have been neglected in the first sector studies.

It was soon evident that part of the missing record of innovation activities was due to the narrow definition of innovation used. Conceiving innovation as just technical change – probably too narrow for the manufacturing sector too – was definitely unsuitable for detecting innovation activities in the service sector. This was due to the characteristics of the sector itself, first of all the fact that there's no such thing as "the" service sector but there are instead many different activities coexisting under the service umbrella definition. In addition to this, the distinction between product and process innovation is less clear-cut in services than in manufacturing. Also what we

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[3] Product and process innovation are not the only forms that innovation activities can take in the manufacturing sector, of course. But the first definition of innovation – the one focused just on technical aspects - was originally enough to give account of the bulk of those activities in the sector.

[4] As a matter of fact, technological bias and manufacturing bias are so connected that the two expressions are used a synonymous From now on, we will use the two as synonymous, keeping in mind their slightly different origin

[5] Among the last of a long list of scholars, Rubalcaba *et. al*. (2010) argued that the residual character of services, coupled with their association to unproductive activities, are the reasons why "services have often been considered as non-innovative or supplier-dominated recipients of technology" (pg 17).

mean by radical innovation is not the same in both sides of the economy. Additionally, the output of the service sector is typically characterized by intangibility/immateriality, indivisibility and co-production with the user see (see chapter III), so it becomes clear why using the narrow mainstream definition of innovation could not be useful in detecting innovation in services.

Going back to the original width of Schumpeter's definition (see for instance Drejer, 2004), and keeping the idea of innovation as "the successful exploitation of new ideas" (DTI occasional paper, 2007, pg. 64), new dimensions have been added to the technical one for the purpose of studying innovation in services. Van Ark *et al.*(2003) offers a useful definition of innovation in the service sector:

"a new or considerably changed service concept, client interaction channel, service delivery system or technological concept that individually, but most likely in combination leads to one or more (re)new(ed) service functions that are new to the firm and do change the service/good offered on the market and do require structurally new technological, human or organisational capabilities of the service organisation." (pg 16).

In this definition we can find all the elements of the first Schumpeterian formulation – new service, new process, new organization, new market and new inputs – declined in a service-friendly way.

All in all, the definitional question has not attracted much attention in the literature, because, as Fagerberg puts it, "the fundamental question for innovation research is […] to explain how innovations occur" Fagerberg, 2005, pg 9).

2.2) The influence of the debate on "how innovation occurs" on the research of innovation in the service sector

Much like the exploration into the "what" question previously reviewed, the debate of "how" innovation occurs first started in the manufacturing sector. In this sector, the initial attempts of describing the process of generating innovation led to the formulation of a pretty simple and at the same time powerful model: the linear model of innovation.

The strength of the model lies in its simple linear logic. The innovation process is described as a strictly linear sequence of different phases: basic research is the initial

step, followed by progression in applied research, development, production, marketing and finally diffusion. Different nuances of this linear string of phases have of course been proposed during the decades (for an historical review of the genesis and the different versions of the model see, for example, Godin, 2006). But the logic underlying them is the same: the applied research translate the results of the basic research in "something" that is first developed and produced and then introduced into the market and diffused. This "something" could be a new product or a new process of production[6].
The strength of this model is that it has clear implications in terms of policy: to increase innovation you need to invest in basic research and make sure that the chain of transmission between distinguished phases works properly.
This representation of the innovation process was later widely, and perhaps overly, criticised (see Balconi *et al.* , 2010). The important thing here is that, despite the flaws pointed out and the several criticism received, the linear model has framed the way in which we look at innovation. As Chris Freeman (1996) synthesises it:

> "the notion that innovation begins with a discovery in "basic science," proceeds with an application or invention derived from this fundamental work ("applied science"), and ends with the development of a new product or process (an "innovation") was indeed at one time quite influential" (pg 27).

In a reconstruction of its elaboration in historical terms, Godin (2006) shows how the linear model has been conceived in a world of production dominated by the manufacturing sector (the first phase of development of the model traces back to 1920s) and in which there was little room for the service one. When confronted with the issue of detecting innovation in the service sector, scholars' first instinct was to look for something similar to what they have observed in the manufacturing field. Finding nothing quite like the straightforward sequence described by the linear model (as there were very few formalized R&D activities, and in some cases, none), the first conclusion was that actually there was no significant innovation in the service sector. The only innovation in services were those developed in the manufacturing sector and then adopted in the service one, a conviction that has nourished what Gallouj (2002) calls the "myth" of incapability of services to innovate (pg 144).

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6 See section 2.1

This initial attitude towards innovation in the service sector then changed. This is in part also due to the development of other models on how innovation occurs in the manufacturing sector. In a seminal contribution, Kleine and Rosenberg (1986) introduced a new kind of model of the innovation process: the chain-linked model. Instead of a strictly linear and consequential string of steps from basic research to the diffusion of a new product/process, Kleine and Rosenberg describe the innovation as "inherently uncertain, somewhat disorderly, made up of some of the most complex systems known, and subject to changes of many sorts as many different places within the innovating organization" (1986, pg. 302). This leads to a model with loops and feedbacks, where all different phases of the process are interconnected and innovation can come from research but also from design.

So the chain-linked model, as opposed to the linear model of innovation, considers a wide variety of forms of innovation. But what matters in this context is not reviewing all the different models of innovation (on this point see, for example, Teed, 2006) or finally determining if the criticisms of the liner model are correct or not[7]. The important point here is that thinking of innovation in the manufacturing sector in non-strictly linear ways (as for example in the chain-linked model) – side by side with the enlargement of innovation's definition seen in the previous session – has set the ground for the search of different kinds of innovation (not just "technological") also in the service sector.

3) The study of innovation in the service sector: assimilation, differentiation or synthesis approach?

In the last twenty years or so, an increasing number of contributions on the topic of innovation in the service sector have been published, most of them of empirical nature. Trying to fill the gap between the relevance of the sector and the attention until then dedicated to it, scholars in this field have now produced a considerable amount of literature (for a review of the main topics addressed in the literature see Gallouj & Djellal, 2010). On the one hand, this does not mean that the distance from the

[7] In a recent article, Balconi *et. al.*(2010) have argued that most of the critics addressed to the linear model are directed towards what they call a "strong" version of it, suggesting that the majority of them can be accommodated in a weaken version of the same model.

innovation studies in the manufacturing sector has been filled. As Szczygielski (2011) puts it, "research on service innovation, while no longer in its infancy, is still a kid brother of the rich literature of innovation in manufacturing" (pg. 5). On the other hand, from this growing body of literature a dominant way of framing the studies of innovation in the service sector seems to emerge. It simultaneously enables classification of the contributions in the field and constitutes a proper theoretical framework to study innovation in the service sector. This framework is composed by three different approaches: assimilation, demarcation and synthesis.

The first two (the assimilation approach and the differentiation approach) represent two mutually exclusive ways of looking at innovation in services: they start from different assumptions and arrive at different analytical considerations and policy implications.

The third one (the synthesis approach) instead rests on some of the relevant building blocks of the two posts, trying to put together the significant components of both and have a more comprehensive, and to some extent, realistic representation of how innovation occurs in the service sector.

In a way, these three approaches can be seen as resting on three different interpretations of the original Schumpeterian definition of innovation[8].

The assimilation approach reprises the narrow version of the innovation definition, focusing on technical aspects and leaving aside everything that is not a new service or a new production process. The demarcation approach, even if aware of the technical aspects, emphasises mostly non-technical dimensions of the innovation process, resting mainly on those aspects.

The synthesis approach embraces all the aspects of the Schumpeterian definition of innovation with equal dignity, proposing to go beyond the manufacturing-service dichotomy and analyse the innovation phenomenon in all its manifestations without a priori distinction among economic activities.

The three approaches can also be seen in a chronological sequence, with the assimilation perspective standing alone during the initial waves of studies on innovation in services and built mainly with blocks borrowed from the near field of innovation studies in the manufacturing sector. Then a second and distinct approach emerges (the

[8] See section 2.1

differentiation) – in part also for the dissatisfaction of the kind of analysis carried within the first perspective. This second approach relies on new concepts and analytical instruments tailored to the specific characteristics of the service sector. But also this second way of dealing with innovation has soon revealed its limits, creating the conditions for a third approach to emerge. The synthesis approach rests on the previous two and tries to combine different elements of them to reach a more general characterization of the innovation process, both in the service and manufacturing sector. This is consistent with the description that Gallouj and Savona (2009) make of the three approaches, that they see fitting "in what might be considered the natural life cycle of theoretical concerns"(pg. 155).

3.1) The assimilation approach

The assimilation or technologist approach[9] considers the service sector as a simple recipient of innovation developed in the manufacturing one. According to this perspective, services are mere users of (mainly technological) innovation produced elsewhere in the economic system. So if this is true, then studying innovation in the service sector doesn't require any more than marginal modification to the theoretical and empirical instruments developed for the manufacturing one (Coombs and Miles, 2000, pg. 85). This implies also that studying innovation in the service sector is actually studying the adoption of innovation from the manufacturing sector and its subsequent diffusion.

The model of Barras (1986), which is one of the most influential in this family of approaches to innovation, is actually "less a theory of innovation in services than a theory of diffusion within the service sector of technological innovations derived from the manufacturing industry" (Sundbo and Gallouj, 2000, pg 43).

The Reverse Product Cycle (RPC) model (Barras, 1986) describes innovation in the service sector as a three phases process, starting with the application of a new technology (adopted from the manufacturing sector) for the sake of improving

[9] Some scholars separate the technologist approach from the assimilation one (see for example Droege and Hildebrand, 2009), where the first is distinguished from the latter for is almost exclusive focus on ICT. Here we follow the predominant view of considering the two as a single theoretical perspective (see Coombs and Miles, 2000; Gallouj and Savona, 2009)

efficiency. Then in phase two the initial process of innovation is taken to the extreme with the goal of improving the quality of the service. Finally in phase three this process ends in the creation of a radically news service. A typical example of this cycle is the bank sector, where ICT (innovation developed in the manufacturing sector) was first introduced to increase efficiency of the back-office procedures, then was adopted in the front office for enhancing the quality of the services offered and finally leads to the development of a completely new service (the ATM machines).

The RPC model has been subjected to criticisms (for a synthesis of the main ones see, for example, Miles, 2005; Gallouj and Savona, 2009) and, as already stressed, is more close to a diffusion theory than of innovation generation. But this doesn't change the fact that the assimilation approach is by far the oldest and still the most common approach to innovation in services (Gallouj and Savona, 2009, pg 155). This way of conceiving innovation – almost completely focused on technological aspects – sets aside all the non-technological dimensions of the innovation phenomenon, which are crucial in the service sector.

The dissatisfaction with this narrowed view has led to the elaboration of a different – and in many respects opposite – way of analysing innovation in the service sector: the differentiation approach.

3.2) The differentiation approach

The differentiation (or service-based or demarcation) approach starts from an opposite point of view with respect to the assimilation one. Since the service sector has different characteristics from the manufacturing, studying the innovation process with the same theoretical and empirical instrument is inappropriate and misleading. The contributions falling in this approach do not deny the "technology dimension" – the fact that services are (sometime heavy) users on innovation developed in the manufacturing sector – of innovation in the service sector. This approach argues that, if we consider only this kind of innovation, we will overlook the majority of the innovations occurring in the service sector.

Given the characteristics of the service sector output[10], the bulk of innovation that takes place in the sector is hardly classifiable along the traditional manufacturing dimensions of product and process innovation. Going somehow to the other extreme, this approach supports the need for service specific ways of defining and studying innovation.

The practical results of the effort to approach innovation studies in a more service-friendly way is the emerging of a series of "local theories of innovation in services" aiming at "identifying sector-specific innovation behaviours without pretending to generalize them or to provide an all-embracing theory of innovation in services" (Gallouj and Savona, 2009, pg 161).

These theories – for example on distribution, financial services or knowledge intense business services – start from the peculiarities of each and every service and built on it a customised definition of innovation and a specific description of how innovation occurs, relaying on ad-hoc empirical instruments to test it. The results is a very informative theory on a specific service sector, where the specificity is not just of the sector analysed but also of its spatial location.

And this lack of a broad perspective is probably the main weakness of this approach. In the attempt to untie innovation in services studies from the clutches of the manufacturing perspective, this approach has produced analyses that are very interesting and informative about specific service sub-sectors but are at the same time limited in their replicability and generalizability.

From the dissatisfaction with the assimilation approach manufacturing bias and the differentiation approach too specific attitude, a third way of looking at innovation in the service sector has recently emerged: the synthesis approach.

3.3) The synthesis approach

The elaboration of the synthesis or rainbow approach is the logical consequence of the shortcomings of the assimilation and differentiation ones. This approach stands on a completely different conception of the modern economic system. Assimilation and demarcation approaches are implicitly based on the idea of the existence of a clear cut distinction of economic activities between manufacturing and service ones. Starting

10 See section 2.1

instead from the observation that in the post-fordist era the boundary between manufacturing and services activities is increasingly more blurred, the synthesis approach adopts a broader definition of what a product is (goods of service) and what innovation in that product means. In their seminal contribution, Gallouj and Weinstein (1997) reprise Lancaster's idea (1966) to distinguish between a good and the bunch of properties and characteristics that constitute the good itself .[11] This was reframed by Saviotti and Metcalfe (1984), who explicitly define a product "in terms of a set of characteristics [...] which will be called *technical, process* and

service characteristics" (pg 142). They built on this framework to elaborate a more general one, capable of an all-embracing definition of "product" (being it a good or a service). They end up with a modified and expanded framework, where a fourth dimension was added to the original three. In more depth, a product (good or services) is represented by a set of characteristics (vector of final characteristics) resulting from some mixture of technical characteristics (vector of technical characteristics) and competences, both of the provider (vector of provider's competences) and the user (vector of user's competences).

So if we imagine a system of three vectors, all having respectively an infinite number of dummy variables for every possible technical characteristic, provider's competencies and user's competencies, we can describe each and every product (good or service) as a fourth vector of final characteristics, emerging from the interaction of the other three.

This new definition of product allows us to elaborate a more comprehensive definition of innovation. If we have a given configuration of our system of four vectors, than every modification happening to it can be seen as an innovation. Innovation conceived in this way becomes an emerging propriety of a complex systems of interactions between characteristics and competencies vectors[12].

In fact, one of the main contributions of the synthesis approach to the innovation studies is that it sheds light on "the multiplicity of ways through which innovation can be carried out" (Dreyer, 2004, 559).

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[11] In Lancaster own words: "The good, per se, does not give utility to the consumer; it possesses characteristics, and these characteristics give rise to utility" (1966, pg. 134).

[12] As Gallouj and Weinstein put it "innovation can be defined as any change affecting one or more terms of one ore more vectors of characteristics (of whatever kind – technical, service or competence)" (1997, pg 547)

This all-embracing definition of innovation – that takes us back in a way to Schumpeter's original one[13] – allows a description of several different innovation typologies and processes that can occur both in the manufacturing and the service sector, with different levels of intensity and types of impact.

The vectorial characterization of products is also capable of providing a general framework that can adjust different modality and different models of innovation typical of different sectors within the economy.

For example Gallouj and Weinstein (1997) define radical innovation as implying the emergence of a brand new system of vector or a substantial change in their internal structure. Therefore while radical innovation as a complete different set of vectors can be seen as more common in the manufacturing sector, radical innovation as a drastic change of their internal structure is more likely to happen in the service one. So in services, radical innovation often means radical reconfiguration of the system of vectors rather than a radical new product, as it is in manufacturing. Nevertheless, the characteristics approach to innovation accommodates them in the same theoretical structure.

Back to how different modes of innovation can coexist side by side in a synthesis approach, improvement innovation is merely represented by "improving certain characteristics, without any change in the structure of the system" while incremental innovation takes places when "the system is changed marginally through the addiction of a new element or thought the substitution of elements" (Gallouj and Weinstein, 1997, pg 548). Other modalities of innovation – ad hoc innovation, recombinative or architectural innovation and the formalization model – can also be described in terms of vectorial dynamics.

All in all, the synthesis approach overcame the manufacturing prejudice of the assimilation approach and the lack of a general framework of the differentiation approach. But the capacity to embrace the phenomenon of innovation in a more general way that is suitable for analysing how it occurs in both the manufacturing and the service sector comes with a prize in terms of operationality. A full description of a

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[13] See section 2.1

product (good or service) in terms of a system of vectors is in fact extremely demanding both from a conceptualization and a data requirement point of view[14].

Attempts to empirically implement a characteristics-based approach have been made (see for a review of the most recent ones Gallouj and Savona, 2009), but we still have a long way to go before reaching a completely operationalized stage.

The synthesis approach seems the most promising in an economic system where the distinction between what both a "pure" good is and what a "pure" service are, is increasingly meaningless. But it is not possible to fully implement a synthetic approach if we don't have data that are collected in a way that is consistent with the premises of the synthesis approach. The problem in this case would be the incredible effort required to collect data of this kind

4) Measuring innovation in the service sector

The way in which we tackle the problem of how to measure innovation in the service sector clearly depends on how we conceive the innovation process in the sector itself. Not surprisingly, given the three different approaches outlined in the previous section, we can follow three distinct paths to measure innovation in services: assimilation, differentiation or synthesis.

Also, in this case, we can observe the same logic and time pattern. The first and still dominant approach is to borrow the measurement tools directly from manufacturing sector, using the same indicators of innovative input and output also in the service one.

So the first place where researchers looked to find innovation input measures for the service sector was where they had always looked: R&D statistics.

The use of R&D's expenditure and R&D's employees as indicators of innovative input was first introduced in 1963 by the OECD Frascati Manual (latest edition 2002) to have a comparable measure across firms, sectors and countries of the research activity. The R&D intensity - defined as a ratio between R&D expenditure and a measure of output (as for example sales or gross output) - is one of the major R&D indicators. The main advantage of using R&D intensity as a proxy of research activity is the large availability of comparable data. But this type of indicator also has a number of limitations, such as

[14] ON this poin see also Chapter II, session 5

the sensibility to the kind of industrial structure of the economy considered or the inability of taking into account embodied R&D (on the pros and cons of the use of R&D intensity see, for example, Smith , 2005).

The limits of the R&D intensity indicator are more evident when it's used to try to detect the innovative effort in services. This is due to the lack of formalized R&D in the service sector. (compared to manufacturing). So if we use expenditure as an indicator of the R&D, we are systematically underestimating the research effort in the service sector, a phenomenon that Djellal and Gallouj have labelled "innovation gap" (2010, pg 654).

This is not to say that in the service sector there are no R&D investments –in fact, they are growing (see Miles, 2005, pg. 436) – but that R&D intensity indicators can tell us just part of the story.

The same downward bias emerges when another typical indicator of innovation output in the manufacturing : patents.

A "patent" can be defined as "a public contract between an inventor and a government that grants time-limited monopoly rights to the applicant for the use of a technical invention" (Smith , 2005, pg. 158). Patents' count as indicators of innovative output and have many potential applications due to the vast amount of accessible data (as in the case of R&D statistics). Nevertheless this kind of data also has known limitations, like the fact that all the peculiar features of the service sector output – intangible, indivisible and co-produced with the user (see chapter III) – don't make it a natural candidate for being patented . We also have to add that the patents' count is an indicator that has a strong technological dimension, whilst most of the innovation happening in the service sector is of a non-technological nature. Recently, some attempts have been made to use trademarks statistic to study innovation in services, but this type of data also has important limitations (see on this point, among others, Hipp and Grupp, 2005).

R&D intensity and the patents' count are among the main indicators of what we have labelled as "assimilation approach". The dissatisfaction emerging from this kind of indicators limits, that make use of data collected for other purposes and readapted for the sake of innovation studies, has also grown in the assimilation field itself. This has pushed researchers towards the direct collection of data through surveys designed with the specific purpose of detecting and measuring innovation. So surveys that are tailored to the theoretic notions of what innovation is and how it occurs have been developed.

However, the kind of innovation these first surveys were looking for was mainly the one existing in the manufacturing sector, so their structure was affected by a strong technological bias from the beginning.

Archibugi and Pianta (1996) distinguish between two different approaches to innovation surveys: the “object” approach and the “subject” approach. They both adopt a definition of innovation as the commercial exploitation of a new process or product and they are both capable of describing how innovation occurs (Smith, 2005, pg. 161). The main difference between the two is their unit of analysis. On one side, surveys in this “object” approach have the single innovation itself as unit of analysis. This means these studies count the number of innovations introduced and then they attached to this information other data regarding the firm introducing it. On the other side, the unit of analysis of a “subject” survey is the single firm. Instead of just collecting information about innovation itself, the subject approach “also allows one to gather information on various aspects related to innovative activities, as well as on non-innovating firms and on the factors that hamper innovation.” (Archibugi and Pianta,1996, pg. 456).

The main example of an object kind of survey is the SPRU database (for a brief description see, among others, Smith, 2005), whilst the main example of a subject approach is the European Community Innovation Survey (CIS)[15].

Both approaches have pros and cons and a full description of their characteristics is not the aim of this paper (on this point see Archibugi and Pianta, 1996). The point that is important to stress here is that both kinds of approaches were conceived with the manufacturing sector as benchmark.

Another way of classifying the surveys carried out to have direct measures of innovation is suggested by Djellal and Gallouj (2000) and taken up later by Drejer (2004), in which we divide the empirical analysis according to the theoretical framework behind them. Surveys based on the assimilation approach are labelled “subordinative”, while surveys are defined “autonomous” if they are elaborated from a demarcation point of view. The theoretical dichotomy “assimilation vs demarcation” approach is also projected on the empirical instruments worked out to have direct measures of innovation. So a subordinative survey uses questions intended for

15 See section 5

manufacturing also for detecting innovation in services, while an autonomous survey will elaborate specific enquiries to take into account the peculiarities of services.

CIS is a typical example of a subordinative survey, first thought and used to measure innovation in the manufacturing sector and then extended (with initially very few modifications) to the service activities[16].

The two different kinds of classification criteria are not mutually exclusive. They can instead be combined to obtain a two-by-two table in which we can distinguish "subordinative and subject" surveys (like the CIS) from "subordinative and object" (like the SPRU database) and also "autonomous and subject" from "autonomous and object" surveys[17].

The subordinative surveys are often large scale ones with data comparable across countries, whilst the autonomous are focused on specific sectors in specific national or regional context, producing data of a more case study typology[18].

The question of the approach chosen to design the survey used to collect directly data on innovation is not a trivial one. The way in which we conceive innovation and the innovation process shapes the tools we use to measure and in the end influences the results of our analysis. For example, Drejer (2004) claims that the findings of some studies using early CIS data about the presumed similarities between innovation in manufacturing and service sectors can be strongly biased by the subordinative nature of the CIS survey itself. In her own words: "these findings of similarities between the two groups could be a direct cause of the assimilation approach though, as it takes a technological approach to innovation, and thus is likely to ignore possible differences related to non-technological innovations" (2004, pg 554).

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16 See section 5.

17 The combination "autonomous and object" is more an hypothetical than a real one. This is due to the marked technological dimension of the object perspective - focused on detecting radically new products - which doesn't go along well with the claim of the autonomous surveys of studying innovation keeping into account the distinct characteristics of services.

18 In analogy with what we have seen concerning the three different theoretical approaches to service innovation, we will expect to have also a synthesis approach to innovation surveys. But the open problems on how to operationalise the synthetic approach don't allow the development of a fully consistent family of synthetic measurement tools. As long as those problems are not solved, it will be difficult to design and implement a synthetic survey. Until then we rely on the very diffused subordinate ones also if we acknowledge the fact that we are now leaving in a "rainbow economy" (Coombs and Miles, 2000, pg 96).

So the kind of survey that we use for gathering our data seriously matters. And for compared analysis at a national level, the one that is by far the most used in the empirical studies is the CIS survey. Reconstructing its origin and understanding its characteristics can increase our awareness when we deal with CIS data, being conscious not only of their potential uses but also most of all of their actual limitations.

5) The use of Community innovation Survey (CIS) for detecting innovation in the service sector

The Community Innovation Survey (CIS) is the main survey carried out in the Europe Union for collecting data on innovation in the member States[19] at firm level. Before the analysis of the problems emerging from the use of these data in empirical studies – both in the manufacturing and particularly in the service sector – it is useful first to briefly sketch CIS surveys evolution thought time and how the CIS data have been exploited in innovation studies.

5.1) The evolution of CIS survey over time

The CIS survey was designed to address the increasing demand for direct measures of innovation, due to the limited kind of analysis allowed by the use of "just" R&D and patent data[20]. The first edition of the OECD Oslo Manual (1992)[21] was the theoretical basis for the elaboration of the first CIS survey (CIS-1) in 1993, carried out as a pilot on 96180 firms scattered in 13 EU countries (with an aggregate response rate of 44%) and covering only the manufacturing sector (Arundel *et al.*, 2008, pg. 6). The definition of innovation used in the first edition of the OSLO Manual (and adopted in the first wave of CIS survey) was centred on its the technological dimensions[22]. The focus didn't

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[19] A different number of countries has participated to each wave of the survey. Starting from CIS 4, the survey was carried out in each member State and also in the candidate States and in some other European countries like Norway and Iceland

[20] See section 4

[21] Also in other context outside Europe the Oslo Manual guidelines for constructing survey on innovation where followed or similar manual were elaborated.(like the Bogotà Manual for Latin America). So CIS-like surveys on innovation have been carried out in different countries of the world (for a review see Bogliacino, *et al*., 2010).

[22] Also if the existence of other different aspects of innovation was acknowledge, the focus was only on technological innovations that "comprise new products and processes and significant

change much in the second edition of the Manual (1997)[23], and so also the next wave of the survey (CIS-2, carried out in 1997) was based on a technological definition of innovation. However, it's worth noticing that a section in the annex of the 1997 Oslo Manual is dedicated how to collect data on non-technological innovation. This second edition of the survey was the first extended in some countries also to firms in the service sectors. In the CIS-3 (2001) a question on the non-technological change was introduced, but only with the next wave (CIS-4 in 2005) a new section on organizational innovation (and its impact) and marketing innovation was introduced. Every survey covers the three year period before the data collection phase. So for example CIS-4, carried out in 2005, asks for information about the innovation activities of the period 2002-2004. From CIS-4 on, the survey is carry out on a regular basis, with main waves every four years and a light version of the questionnaire every two years. To avoid confusion, the different new waves are now commonly named after the final year covered by the survey itself, rather than with a progressive number. This is the reason why the following two waves are referred to as CIS-2006 and CIS-2008[24]. CIS-2006 was the first light edition and has been designed to be compatible with the previous CIS-4, so it is mainly based on the 1997 version of the OSLO Manual. CIS-2008, launched in 2009, is the first edition that fully implements the recommendation of the OSLO Manual's latest revised version (2005). So the definition of innovation is not restricted to the technological aspects[25] and there are distinct session for dealing with organizational and marketing innovation. During each wave of the survey, changes and improvements have

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technological changes of products and processes. An innovation has been implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation)" (OECD, 1992, pg 28).

[23] Innovation was again defined as technological innovation and in the following way "Technological product and process (TPP) innovations comprise implemented technologically new products and processes and significant technological improvements in products and processes. A TPP innovation has been implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation). TPP innovations involve a series of scientific, technological, organisational, financial and commercial activities. The TPP innovating firm is one that has implemented technologically new or significantly technologically improved products or processes during the period under review." (OECD, 1997, pg 31).

[24] In some papers or also in some official documents it's still possible to find CIS-5 and CIS-6 respectively instead of CIS-2006 and CIS-2008.

[25] In this third and (for now) last version, an innovation "is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD, 2005, pg 41).

been made, deleting questions and introducing new ones. However, starting from CIS-3, a basic core structure has emerged [26] and has remained stable over time (different editions) and space (different countries).

This typical structure [27] of a CIS questionnaire is constituted by a first part where general information on the respondent firm (like the number of employees or the turnover) are collected, followed by the questions of the kind of innovation (if any) introduced by the firm in the last three years. This could be a product (good or service) or a process innovation, new to the firm or new to the market. If the respondent firm has introduced at least one of the these innovations, then it is classified as "innovative". Also, failed innovative activities – meaning innovative activities that did not result in the introduction of a new product or process – are considered for a firm to be counted as "innovative". Than the following questions – regarding innovation inputs and resources devoted to innovation (including public funds), sources of innovation, innovation cooperation and objectives of the innovation activities – are intended just for the innovative firms. The firm first labelled as "non innovative" jumps directly to the next block of questions, where all the firms are tested for other different kinds of innovation: organizational innovation and marketing innovation. In this last block, other information is requested, but this varies among different waves and different countries[28].

The evolution of the CIS surveys, with questions amended, added or deleted and with the extension to all the service sub-sectors, clearly reflects the parallel evolution in the definition of innovation as codified in the Oslo Manual. The importance of non technological aspects of innovation has been increasingly acknowledged and consequently questions regarding these features have gained space in the questionnaire. This was not due only to the necessity of including the service sector (where these kind of innovations are the most common) in the survey, but also to the recognition that, even in the manufacturing sector, innovation is not just new product or new process. In

[26] For a description of the evolutions of the first four waves of the survey see, for example, Arundel *et al*., 2008.

[27] The CIS questionnaire in not exactly the same across all EU countries. The core questions are the same, but every country can slightly change their order or can require some extra information. Those differences are sometimes not only marginal but are substantial and affect the interpretation that we can give of the data collected (see section 5.3).

[28] See section 5.3

other words, CIS survey has moved from a technological definition of innovation to a more Schumpeterian one, following the development in the Oslo Manual.

5.2) The use of CIS data for analysis on innovation

A review of the empirical literature that has used CIS data for analysis in the manufacturing sector or in the service sector is far beyond the scope of the present paper (see Arundel *et al.*, 2008 or Mairesse and Mohnen, 2010; for a specific one on the service sector see Gallouj and Savona, 2010).

The important point in the present context is that the same kind of analysis using CIS data previously performed in the manufacturing sector, has been later replicated by the studies on the service sector. So we can roughly divide the empirical contributions based on CIS data in two big families: those that use econometric methods or multivariate analysis techniques and those that elaborate synthetic indicators and scoreboard[29].

The first kind of analysis has looked into CIS data for making taxonomies of innovative firms, for correlations and for causal relationships between the innovative performance and other relevant economic indicators (such as employment and turnover). There are three main types of issues that researchers have tried to address using these techniques. The first regards the characteristics of the firms that innovate and the kind of innovation introduced (the "who and what" questions). The second issue is about the innovation strategies adopted by the firms that actually innovate and the reasons for doing it (the "how and why" questions). The third one cancers the effects of innovation on some indicators of the firm's performance (the "what impact" question). An increasing number of studies have tried to answer one or more of these questions performing different kinds of analysis on CIS data (176 research papers up to 2006, according to Arundel *et al.*, 2008, pg. 14) A predominant approach seems to emerge among them, particularly amongst those trying to answer the "what effects" question. To account for

[29] The two groups are not mutually exclusive and this division is mainly for the purpose of the present exposition.

the problems of endogeneity and selectivity[30] a system of three simultaneous equations was elaborated by Crépon, Duguet and Mairesse (1998). The CDM model uses an equation to explain the quantity of R&D, and employs the result as input in a second equation explaining the innovation output, which is then an explanatory variable in the final productivity equation (for details see by Crépon *et al.*, 1998). In the service sector, the questions posed are nearly the same, meaning that the techniques used to answer them are also the same. Furthermore, in service studies, models using systems of equations are becoming popular (see, for example Cainelli *et al.*, 2006 or Lopes and Godinho, 2005).

The other "family" of empirical contributions uses the CIS data for elaborating descriptive statistic and, most of all, synthetic indicators. The aim of these indicators is to measure the country or sector's innovative performance, offering a tool for policy makers easy to interpret and suitable for comparative analysis. The increasing success of synthetic indicators covering innovation is indeed due to the fact that, when are not misused, they can "quickly summarize complex data in a way that can identify problems and help build political support for government action" (Arundel and Hollanders, 2008, pg. 29).

In the context of the EU countries, one of the most diffused synthetic indicators is the Innovation Union Scoreboard (IUS), that since 2010 has replaced the European Innovation Scoreboard (EIS)[31]. IUS is a means of comparing the innovative performance of the European countries and of monitoring Europe 2020 strategy implementation. In line with its precursor, the IUS is a collection of 3 main kinds of indicators (enablers, firm activity and outputs indicators) that capture 8 different innovation dimensions for a total of 25 distinct indicators. It provides a Summary Innovation Index (SII), which is a composite indicator computed aggregating 24 IUS indicators[32] (for a detailed description of the aggregation methodology and all the

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[30] See section 5.3

[31] In its last formulation, the EIS provides a composite index, the Summary Innovation Index, computed as an unweighed average of "29 innovation indicators, grouped over 7 different innovation dimensions and 3 major groups of dimensions" (Hollanders and van Cruyse, 2008, pg 2). For a review of the different formulations of the EIS see, for example, Arundel and Hollanders, 2008.

[32] They are 24 and not 25 because one of the, "High-growth innovative enterprises as a percentage of all enterprises" is still under development.

innovation indicators, see IUS 2011 report, 2012). Out of these 24 indicators, 6 are derived from the CIS survey.

For the service sector, a specific synthetic index has been developed: the Service Sector Innovation Index (SSII). Also this index is an unweight average of a series of 24 indicators covering seven themes[33], indicators that "are intended to reflect the main elements of innovation performance in the services sector" (Kanerva *et al.*, 2006, pg 4). These indicators, that can be calculated at a country level or at a sectoral level, allow for cross countries and cross sectors comparisons (see for a detailed description Kanerva *et al.*, 2006, Arundel *et al.*, 2007, Hollanders and Kanerva, 2009). In the case of the service sector index, 22 out of these 24 indicators are computed using data from the CIS survey.

Analyses that rely on CIS data – both in the manufacturing and in the service sector – have to reckon with their limits and problems.

5.3) The limitation and the problems of the use of CIS data in empirical analysis

Researchers have always been aware of the problems connected to the use of CIS data for econometric analysis. Some of the changes of the survey over time are mostly due to the attempt to address part of the main issues emerging in the first studies. Also the CDM model described in the previous session was, in fact, an attempt to cope with two of these problems: endogeneity and selection bias.

Endogeneity and selection bias are two of the main issues to deal with when we use CIS data for econometric analysis, as pointed out clearly in a recent article by Mairesse and Mohnen (2010). The cross-sectional nature of the CIS data creates an endogeneity problem that makes it difficult to tell the causality direction of relations between variables (Mairesse and Mohnen , 2010, pg 10). The selectivity problem is instead due

[33] The seven themes in which the indicators are grouped are: human resources (3 indicators), innovation demand (2 indicators), technological knowledge (2 indicators), non-technological change (5 indicators), sources of knowledge/diffusion (7 indicators), commercialisation (2 indicators) and intellectual property (3 indicators). For a detailed list of the indicators see (Kanerva *et al.*, 2006, pg 22).

to the fact that some questions are designed to be answered only by "innovative firms"[34] and that generate censored variables. (Mairesse and Mohnen , 2010, pg 9).

These two problems are specific to the use of CIS data for econometric analysis. Mairesse and Mohnen (2010) also spot other three issues that affect the construction of synthetic index as well[35]. The first one is the fact that most of the variables detected are qualitative, which means that we have less information compared to a quantitative variable. Among these qualitative variables, the majority are constituted by categorical dichotomic variables. The other two problems are connected: one derives from the subjective nature of the CIS [36] and the other concerns the quality of data and the presence of measurement errors in the variables collected. Adopting CIS a subject approach, "many of the variables, qualitative and quantitative as well, are of a subjective nature, being largely based on personal appreciation and judgement of the respondent" (Mairesse and Mohnen , 2010, pg. 9). The issue of the quality of the collected data follows directly from this and is coupled with the probability of a measurement error that is a common feature of all surveys.

Those problems are common to all the analysis using CIS data, whether their focus is on the manufacturing or the service sector. Some of them – like endogeneity or selection bias – can be solved or mitigated by using particular estimation techniques (as the case of the CDM and multiple equation models), merging different CIS waves to obtain a panel dataset[37] (that allow to control for endogeneity) or merging the CIS with others surveys with additional information at firm level (to correct for selection bias). We also have to keep always in mind that CIS data is not collected principally for the sake of econometric analysis, but for helping the courtiers that gather them "to benchmark and monitor their innovation performance on the basis of appropriate indicators and scoreboard" (Mairesse and Mohnen , 2010, pg. 11).

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34 See section 5.1

35 For synthetic indicators, aside the quality of the data, the main problems are the choice of the indicators to include and the aggregation form to use for the synthesis. For a discussion of these problems and a justification of the aggregation form used see the technical appendix in the IUS 2011 report, 2012

36 See section 4

37 In some countries this as actually been done, like in Germany (with the so-called Mannheim panel) or Spain.

Other problems – like those linked to nature of the variable collected or the measurement problems – are in a way intrinsic to the CIS itself and can be partially addressed only changing the structure of the survey.

When it comes to the service sector, we have to add to all the issues that we have just discussed those deriving from the original sin of the CIS survey: being born for manufacturing sector studies. CIS is in fact a typical example of a subordinative survey[38], designed for the manufacturing sector and then amended to be used also in the service sector. This comes out clearly from the history of the CIS itself, initially restricted only to the manufacturing sector[39], and affects its ability to detect innovation in services.

For example in the case of the Italian CIS, also in the latest version of the questionnaire, the way in which questions are organized still echoes the initial manufacturing bias. The questions on innovation inputs, sources and objectives are restricted only to firms introducing (or that have tried to introduce) a new product (good or service) or process (the firms tagged as "innovative"). This is on the one hand done to ensure comparability with the previous waves of the survey (where innovative firms where defined in the same way). But on the other hand it reflects the idea that the only innovative firms are those introducing (or trying to introduce) some technological innovations, as if other forms of innovation (such as organizational or marketing, typically more common in the service sector) are not enough to qualify a firm as "innovative". To be fair, the two sessions on organizational and marketing innovations have separate questions for innovation objectives, but not for the resources and the sources of innovations[40]. Also the fact that the user-producer relation, that is one of the main drivers of innovation in

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38 See section 4

39 See section 5.1

40 In the Italian CIS-2008, compared to the previous waves, there have been also two major changes. First, the final section is a newly introduced one about the environmental impact of innovation. Second, the questions on the factors hampering the innovative activities of the firm and on the instruments used to protect the firm's IPR have been removed from the questionnaire. This elimination of the questions on obstacles and IPR protection has exacerbated the censored character of the CIS survey. Now, if an Italian firm does not introduce any process, product, organisational or marketing innovation, than we don't have a single information about the respondent, except for the very general ones.

the service sector, is virtually unexplored is yet another clue of the CIS survey's technological prejudice [41].

There is somehow a path dependency in the way in which we collect data on innovation through CIS survey. This creates a sort of lock-in effect that leads us to focus mainly on technological innovation and consider other forms of innovation (more common in the service sector) as "minor"[42].

6) Conclusions : an integrative approach to data collection?

The issue of innovation in the service sector is important and still not properly addressed . In this paper we have tried to stress the importance of the topic and to reconstruct the debate in the literature on two of its dimensions: the definition of innovation in the service sector and its measurement.

In both cases, we have seen how the initial focus of the infant innovation literature on the manufacturing sector has acted as a sort of imprinting on its way to define and measure innovation. The manufacturing bias has affected the first generation of studies in the service sector, both those which have willingly accepted it and those which have tried to fight it.

The larger spectrum of innovation typologies (compared to manufacturing) observed in the service sector has slowly led to an enlargement of the definition of innovation. From the first narrow definitions focused only on technological aspects we have moved to a broader Schumpeterian definition of innovation. This evolution has also been followed

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41 The role of the client is included among the possible sources of innovation and there's also a yes or no question about the collaboration with the client. But this question in the session reserved to the "innovative firms", so the one generating a technological innovation, while is not posed to those introducing only organizational or marketing innovations.

42 Also if the core questions of the CIS survey are the same across EU countries, their organization is not the same. Also the additional question posed can be different. Just to make a couple of example and without the aim of being exhaustive, if we consider the last 2008 wave, the new session on the environmental impact of innovation is present not only in the Italian but also in the French version, while is absent in the UK or Spanish ones. The question on the obstacles to innovation, abolished in the Italian and French version, is instead still present in the UK and Spanish ones. The French CIS is based on 6 different versions customised for different sectors (wholesale and retail trade, construction, manufacturing, finance, service, transport). The UK 2008 collects the same set of information for all the firms introducing an innovation, without restricting the definition of innovative firms only to the ones introducing a technological innovation.

by the methods that we use to measure innovation, and particularly by the most diffused survey on innovation in the European Union: the CIS survey.

We have sketched its changes through time, highlighting the problems and shortcoming still present today. Some of them are due to its original sin of having being designed for the manufacturing sector.

In this paper we have also seen how a predominant way of framing the studies on innovation in the service sector has emerged in the literature. The assimilation/differentiation/synthesis framework is now a pretty standard way of classifying contributions in the field and study innovation in services.

The integration approach is the most comprehensive and promising, but also the most expensive in terms of operationalization and data requirement.

We need to keep pursuing the synthetic way of studying innovation as the only way to get rid of the manufacturing bias once and for all. This also implies rethinking how we collected data on innovation, especially how we structure and conduct the CIS survey. We have two possible alternatives: either we try to correct some of the CIS drawbacks, changing its nature towards a more synthetic one; or we decide to develop a new integrative innovation survey. All these issue are worthy of further research.

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III. Innovation and Productivity in Services. A review of conceptual and methodological issues and a way forward[43]

1) Introduction

Processes of tertiarisation – i.e. long-term structural changes in the sectoral composition of economies toward service sectors – have been shifting over time from being a cause for concern linked to de-industrialisation, to representing a leverage for countries' competitiveness linked to the growth of 'knowledge-related activities'[44]. Both of these views revolve around a key, age-old economic concept: productivity.

The traditional way of conceiving and measuring productivity – as argued in this paper - is in general not well-suited to be applied to intangible economic activities. Yet, relying on productivity figures, Kaldor (Kaldor, 1966) analysed and explained the "causes of slow rate of growth in the United Kingdom". Kaldor sparked a whole stream of research concerned about the dematerialisation (as a synonymous of de-capitalisation) of the economy. In the same vein, 'knowledge optimists' relied on the same concept of productivity to come up with opposite figures and implications for the growth of services.

In between the two views – and over time - technical change and especially the dramatic diffusion of Information and Communication Technology have largely impacted on the productivity figures of services – and the overall economy – and therefore put in perspective some of the concerns about de-industrialisation.

Overall, exception made for Griliches (1992), not many scholars have gone in depth into conceptualisation and measurement of productivity in services and disentangled issues like (i) the appropriateness of the standard concept and measurement of productivity for services; (ii) the account of technical change and innovation in both the conceptualisation and measurement of productivity in services; (iii) the proposal of new, better ways to conceptualise and measure productivity in services, should traditional

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43 This chapter is based on a paper co-authored with dr. Maria Savona. Although both authors equally contributed to the paper, Sections 2, 3 and 4 can be attributed to Nicola Grassano and Sections 1, 5 and 6 to Maria Savona.

44 The literature has increasingly covered the role and impact of 'knowledge-intensive business service' (KIBS))for a review, see Muller and Doloreaux , 2009).

indicators of productivity be found misleading or mis-representing when applied to services.

This paper aims to systematise the literature according to whether it has responded to the questions above and through the lenses of the 'Kaldorian' versus 'Knowledge economy' alternative approaches[45]. These are summarised below and reprised al large in the next sections.

Among the Kaldorian scholars, Griliches extensively worked on productivity and extended the analysis to services. In his seminal contribution (Griliches, 1992), he pointed out two possible explanation of the US productivity slowdown in the eighties: one is an intrinsic lower technical progress in the service sector compared to manufacturing, the other is a potential mis-measurement of productivity in the service sector due to difficulties in calculating output and prices.

The first explanation lay down an argument in line with the 'Kaldorian' strand of research, originated by the work of Baumol (1967), whose unbalanced growth model identifies service sector as a non-progressive sector in which labour productivity is stagnant as a result of an inner low level of technical intensity. The joint role of this and of rising wages (deriving from the fact that wages increase of the same amount in the entire economy according to productivity gains of the progressive sector) causes a limitless cost increase with a corresponding slowdown of the economic growth (this phenomenon is known in the literature as the Baumol's cost disease).

The second explanation relates to the fact that specific characteristics of the service output (like intangibility or interactivity) can affect the capability of measuring it, leading to a mis-measurement of productivity. In addition, output's prices measurement can be problematic in the service sector for the difficulty of taking into account quality changes or because for some services – like most of non-market services there is simply no price .

These two possible and not mutually excluding explanations have in turn led to two distinct but connected lines of research. The first one tries to question Baumol's argument of the "natural" low technological content of the service sector, especially in

[45] We are aware that there are two interlinked issues that should be accounted for when tackling these questions: one is merely conceptual and relates to the output definition of and price attribution to non-physical economic outcomes. The other one is, more pragmatically, related to the provision of a comparable framework to account for technical change embodied in both goods and services.

the light of the productivity increase registered form mid-nineties on in the US, and the continuous increase of the service sector's contribution to national income (this is true for all the developed economies) (see Bosworth and Triplett, 2007, Inklaar *et al.*, 2008 and Timmer *et al.*, 2011).

The second strand deals with measurement issues deriving from services' specific characteristics and tries to identify methods to calculate output and prices for the different services' typologies. (see Wölfl, 2003 and Diewert, 2011)

Along with these connected mainstream lines of research, a third one emerged. This alternative strand of literature, while sharing concern about measurement problems, question the validity of the concept of productivity itself. It distinguishes between service sectors in which the problem is measurement and service sectors in which the concept of productivity is meaningless and alternative measure of performance should be used (see Djellal and Gallouj, 2008).

The paper is organised as follows: we first recall the traditional productivity indicator and evolution of methodological tools to deal with it (Section 2), which leads us to discuss the supposed inner low technical content of services in the light of the recent productivity trend (section 3) and then on the measurement issues deriving form services' characteristics (section 4),which also explores the limits posed to the application of the concept of productivity by services' specificities. Section 5 summarises the main issues at stake and proposes a way out to sort the pending ones, hinting at the possible alternative measure of performance beyond the concept of productivity itself in the form of a research agenda.

2) Concepts and measurement of productivity and implications for services

2.1) What is productivity?

To measure productivity first we need to define the concept of productivity itself, concept that broadly speaking is old as the economic theory[46].

[46] The idea of productivity was already present in the book universally considered the starting point of the modern economic thought: the Adam Smith's 1776 *An Inquiry into the Nature and Causes of the Wealth of Nations*. The first book, dedicated to the causes of the improvement in the productive

In very general and simple formal terms, productivity *(p)* can be defined as the ratio between a measure of the output *(O)* resulting from the productive process and a measure of the various inputs *(I)* used in the production process itself. Therefore $p=O/I$. This straightforward definition is the one usually adopted and implemented, as suggested by the OECD in the 2001 manual on measuring productivity, where it's defined as "a ratio of a volume measure of output to a volume measure of input use" (OECD, 2001, pg 11).

The OECD manual also provides a specification of the main productivity measures used. Different measures are associated to different combinations of output measures (gross output or value added) inputs measures (labour, capital, capital and labour or capital, labour and intermediate inputs). The types of measures that we choose for the output and the inputs determine the properties of the indicator of productivity we compute. Each measure has advantages; drawbacks and limitations that are clearly investigated in the manual. For example, labour productivity in terms of gross output has the advantage of being easy to measure, without requiring information on intermediate inputs. But it's a partial measure of productivity very keen to be misinterpret.

Labour productivity in terms of value added has the same advantages and drawbacks, plus the problems connected to the deflation procedure. Also capital productivity based on value added, while being easy to read, suffers for the same limitations of all partial measures of productivity – reflecting the joint influence of different factors (not only capital). Capital-labour MFP based on value added overcomes some of the limitations of partial measures of productivity, but has be proven not to be a reliable measure of shifts in technology at firm or industry level. Finally, multifactor productivity measures - such as the KLEMS multifactor productivity – have the conceptual advantage of taking into account the effect of all the productive facture employed, but are very requiring in terms of data needed to compute them.(for more specific details on each productivity measure, see OECD, 2001, pp 13-18).

The concept of productivity should be distinguished from concepts of performance, effectiveness and efficiency.

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powers of labour, describes how the division of labour increase its productivity, meant as the relative amount of output produced giving the inputs used in the production process.(Smith, 1776 (eds. 1998)).

As recalled by Djellal and Gallouj (2008), productivity is different from performance – the capacity of reaching some predetermined goals – and from effectiveness – the actual realization of goals without any consideration for the quantity of output produced or the costs sustained.

Productivity is also different from efficiency – the capacity of reaching some predetermined goals while at the same time minimizing the costs – that could be financial efficiency (known as profitability) or technical and operational efficiency. What problems comes up (if any) when we use the same concept in the service sector? Before trying to answer this question, we first consider how productivity is actually measured.

2.2) Measurement techniques

We can distinguish two broad families of techniques for measuring productivity: index methods and productivity frontier methods.

2.2.1) Index methods

If productivity is the ratio between output and inputs, the simplest way to measure it is to calculate this ratio using the a measure for the output(s) and a measure for the input(s).

Ratios can represent partial measures of productivity – i.e. the ratio between output and one of the inputs used in the production process, as for example the labour productivity or the capital productivity – or multifactor productivity measure – the ratio between output and two or more inputs. Output can be measured in terms of gross output or value added OECD 2001, section 2.1).

Diewert (1992) points out that there are in the literature six different approach to productivity measurement[47] that have been suggested and he shows that they work quite well in the simple one output one input case. However, modern economies are composed by multi—output and multi—input firms (in the manufacturing as well as in

[47] These methods are: 1) the direct quantity index method, 2) the change in technical coefficient method, 3) the deflated revenue divided by deflated cost method, 4) the Craves and Christensen method, 5) the deflated revenues divided by an input of quantity index method, 6) the Jorgenson and Griliches price index method. For the analytical formulation and the technical description see Diewert (1992, pp 164-169).

the service sector) and this complicates the computation of a simple ratio . The main problem is that in the multiple outputs and multiple inputs case different techniques give different productivity estimates.

To overcome this problem, a different class of methods can be used: the index number methods.

Instead of the ratio of simple measure of outputs and inputs, the index number methods allow to deal with multiple outputs and inputs with different prices. Various types of index numbers can be computed, with different properties depending on the weight structure and on the functional specification chosen. One of the most used is the Malmquist productivity index, which is a productivity index built up on the base of distant functions (see Caves, *et al.* 1982) and can be also be calculated using a DEA function (see section 2.2.2).

The critical point in using index numbers is often the choice of the functional form to employ (for a description of some of the main index numbers employed in productivity studies and relative problems see, for example, Diewert (1992)).

In both cases – simple ratios and complex index numbers – the accuracy and precision of the measure depend on the availability of reliable output and input data (on physical output, volume or value added depending on the sector considered) and of adequate price indexes. And it's the availability and accuracy of these data one on the major problems when we compute a productivity index, both in the manufacturing sector and (particularly) in the service sector (see section 2.3).

2.2.2) Productivity frontier methods

A different approach to measure productivity is to estimate a productivity function. Instead of a ratio, we compute a productivity function that expresses the productive possibility of the unit under consideration. As Farrell (1957) points out in his pioneering contribution, we can estimate an empirical productivity frontier of the most efficient productive unit and then measure the difference between this frontier and the actual one of the unit considered.

From this basic intuition of using the concept of productivity function to measure productivity, two main approaches have been derived, distinguished by the nature of the production function considered.

Farrell'(1957) computes a productivity function on a real production unit and uses it to assess the performances of the others. These techniques are called non parametric because they don't assume an a priori functional form for the production function. The most popular among them is the data envelopment analysis (DEA) (Charnes, *et al.*, 1978), that consists in empirically estimating the production frontier of the best performer in term of technical efficiency and using it as a yardstick to evaluate the performances of the other units considered.

This kind of approach can be used to calculate the distance between the actual productivity function of the unit considered and the estimated best one and then using this distance to compute a Malmquist productivity index (see section 2.2.1)

Parametric methods rely instead on an a priori definition of a specific functional form for the unit production function (typically a Cobb-Douglas form augmented with others inputs rather than only labour and capital, such as energy inputs or intermediate material inputs) and then estimation of the parameters to derive a direct measure of productivity.

In both cases - parametric and non-parametric techniques - we can specify the function as deterministic (without error term) or stochastic (allowing for an error term that can incorporate measurement inaccuracy).

Stochastic parametric techniques are extremely powerful in estimating parameters and taking account of non-Hicks neutral technical change but are sensible to problems like omitted variables and selection bias (for a recent review see Van Beveren 2012).

Also in the case of productivity frontier methods – as for simple ratio and index methods – it's fundamental to have precise data measuring inputs, outputs and their prices.

2.3) Unresolved issues

The most common – and unresolved – issues of productivity measurement techniques are related to (i) problems of aggregation (ii) reliability of data on output and input volumes (iii) availability of prices for all economic activities We briefly revise them and introduce service specific issues within these.

2.3.1) Level of measurement and aggregation issues

Productivity can be measured at different levels: firms, organization, industry, or national level. In principle, if we measure productivity at the firm level, we should be able to get an index of productivity at the industry level "just" by aggregating the different measures obtained for all the firms belonging to the particular industry considered. Similarly, we should be able to do the same as we move up to the national level.

But, as Triplett and Bosworth (2004) point out, two major problems arise when we first compute industry productivity and then we try to aggregate the results to get a single comprehensive measure:

> First, aggregate productivity is not just the aggregation of productivity changes within the individual industries. Aggregate productivity can also change because of reallocations across industries. [...] A second issue concerns combining gross output productivity at the industry level with value added productivity at the aggregate level (Triplett and Bosworth, 2004, pp 20-21).

These two problems – how to take account of the reallocation effect and how to combine gross with value added measures – are common to the manufacturing and service sector and can be tackled using different formulas (see Triplett and Bosworth (2004) for a discussion[48]).

2.3.2) Reliability of data and measurement of input and output

A valid measure of productivity relies on appropriately measured inputs and outputs. The task of counting how many inputs and how many outputs are involved in the production process may seem an easy one, though the level of difficulty depends on the sector and aggregation level considered.

In the manufacturing sector, counting the output units produced and the inputs unit employed might be pretty straightforward, when we consider a firm producing a single

48 Triplett and Bosworth (2004) deal with productivity problems in the service sector, but as far as aggregation is concerned, their discussion is valid for all the sectors of the economy.

type of output using a single type of input. But firms always use more than an input in the production process and often are multi-outputs, making the computation more difficult. More problems arise on the inputs side, namely on the ability to find satisfying volume measure for labour, capital and the other inputs entering the production process, such as energy or intermediate inputs (for a recent reviews of the problems connected to each kind of input and the actual measures used at the national account system level see Diewert 2007).

In the service sector, the characteristics of the output make the measurement problems more severe.

In particular, the fact that the typical output of the service sector is in some degree intangible makes clearly difficult to count it as a whole or in part. Also, this makes it harder to separate units of output . In addition, the production process in the service sector usually involves the contribution of the customer himself, confusing things a little bit more (Gadrey, 1988, McLaughlin and Coffey, 1990, Gadrey and Gallouj 2002). So intangibility/immateriality, indivisibility and co-production with the user make the service output not easy to identify and count, often leading to mis-measurement.

This mis-measurement takes the form of an underestimation of the volume of service sector's output and this has been suggested as one of the main reason of the low productivity figures registered in the sector (see, for example, Triplett & Bosworth, 2003). If the productivity slowdown registered in US and Europe in the seventies and eighties (we reprise this issue in section 3.2) has been due to mis-measurement of the output in the service sector is still a matter of debate (see Griliches, 1992; Sichel 1997). But anyway there's no doubt that the specific characteristics of the service sector's output make the use of measurement concepts and techniques developed for the manufacturing difficult to apply unless we make some adjustments.

2.2.3) Price attribution and data reliability

One of the main issues arising around price attribution and price data reliability – which holds for both the service and the manufacturing sector – concerns the capability of price indicators to reflect changes in quality of the good or service provided. As stressed by Grönroos and Ojasalo (2004), the standard productivity concept is based on a constant quality assumption: in the process of effective transformation of inputs into outputs quality remain unchanged. So any change in quality will not be recorded, giving rise to another potential source of mis-measurement and biased productivity indicators.

In addition we have also to consider that a change in the inputs may sometimes alter – especially in services – the perceive quality of the outputs. This can create a twisted effect. Let's say, for example, that a change in the combination of inputs used led to an increase in the outputs and that leads to an increase in productivity (computed using a standard output over input ratio). But let's assume that the variation in inputs is perceived by the consumers as a decrease in their quality and therefore in the output they originate, leading to a reduction of demand for that particular output. So an improvement in productivity is ironically translated in a worse economic performance (Grönroos and Ojasalo, 2004, pg. 415).

In general, and from an innovation theory perspective as well, the puzzle is both conceptual and methodological: to what extent changes in quality of the inputs or outputs or both represent innovations? And how do we account for innovativeness in terms of quality change? What kind of relation can be established – again, both conceptually and from a measurement perspective – between traditional indicators of product and process innovation and quality improvement? How do we account for quality-enhancing productivity and input saving productivity? These issues will be reprise below.

The second issue concerning how prices enter productivity measurement is simply the lack of data for certain sectors. This is a major problem in the service sector, in particular in the government and in general for non-market sectors, where there is a considerable number of services traded with no corresponding price or at an highly subsidized price. Diewert (2011) suggests three methods for measuring government output in the non-market sector.

These three methods are ordered according to their decreasing desirability . The first approach is the evaluation at market prices or purchaser's evaluations of government and non-market output. The idea is that if we have information about quantity only but there is a comparable market sector for which prices are available, we can use this latter as a proxy variable, possibly taking account for quality variations with hedonic price techniques (see section 2.3.4). If prices of a comparable sector are not available but we have detailed information on the behaviour of the rest of the economy, we can then use as proxy an indirect price index computed on user evaluations. The problem with this kind of method is that often we don't have a real comparable sector or the amount of information request to calculate an user evaluation index is just too costly.

If any of the first type methods is not applicable, the second best alternative is to evaluate government and non-market output at producer's unit cost of production. In this case we use costs as a proxy of prices and we can also evaluate quality changes looking at them from a cost based approach rather than a demand or user one. (for a detailed description of the various specification of these two general methods see Diewert, 2011).

The third methodology is to be used only in case of lack of information on the volume of the output produced by the government, its value and its price. In this case, we assume that the aggregate growth of the output equals the one of inputs used for producing it, both in terms of volume and prices. Clearly with this methodology we set the change in productivity equal to one by definition.

So while the problem of missing prices has sometimes no solution[49], the issue of quality can be tackle using different techniques, most of them based on hedonic prices.

2.3.4) How to deal with quality changes: the use of hedonic prices

The so called "Solow productivity paradox", the idea that "you can see the computer age everywhere but in the productivity statistics"(Solow, 1987, pg 36) has long affected research on the role of ICT in modern economic systems. The discussion of this paradox is beyond the scope of this paper (for a discussion of it see, for example, Brynjolfsson (1993) or Triplett (1999), who examines eight possible explanation of it). What counts here is that ICT is a case in which mis-measurement problems due to the difficulty to take into account quality changes has been an issue long considered and in which a possible solution has been found in the use of hedonic prices.

[49] The issue of productivity in the public sector is too important to be tackled here and is largely beyond the scope of the paper. This is nevertheless part of our research agenda.

Van Ark (2002) identifies four possible categories of measurement problems for ICT, depending if we consider output or input, manufacturing or services. For three of them, the solution is the use of hedonic prices (Van Ark, 2002, pg 8). But what is an hedonic price index? The hedonic prices technique to detect quality changes, first introduced by Griliches (1961) for the car industry, has been largely used in the ICT sector. According to the OECD Handbook of Hedonic Indexes and Quality Adjustments in Prices Indexes (2006): “a hedonic price index is any price index that makes use of a hedonic function. A hedonic function is a relation between the prices of different varieties of a product, such as the various models of personal computers, and the quantities of characteristics in them”(pg. 41).

Hedonic prices are price indexes corrected to take into account quality variations in ICT input and output and are a way to overcome measurement problems related to that changes. Hedonic prices are not without limitations, first of all the considerable amount of information necessary to compute them (for a review of the main critiques to the use of hedonic prices in ICT see OECD, 2006, chapter seven) . But their use can be a viable solution for overcome the quality issue also in the service sector.

2.3.5) What methods for services?

The Eurostat Handbook on price and volume measures (2001) classified the methods employable to measure productivity in the market service sector in three categories: “A methods” are the most appropriate methods, “B methods” are those which can be used in case an A method cannot be applied and “C methods” ore those which shall not be used (pg 4). For each typology of market services the three kinds of methods are described. Inklaar *et. al.* (2008) have collected the inventories made around the year 2000 by each European National Statistical Institute of their own methods of compute productivity, rating them according to the Eurostat A,B,C classification.

According to them, the average percentage of service sector output deflated using A methods was 12 per cent, of B methods 62 per cent and of C ones 26 per cent, with sector like wholesale trade or financial intermediation where the percentage of A methods was zero (Inklaar *et. al.*, 2008, pg. 179).

Although if in the last decade the situation is probably changed and the above numbers referred to European average (hiding difference sometimes considerable among countries), these figures are symptomatic of the difficulties of estimating productivity in the service sector.

3) Productivity and technical change in services: reconciling alternative views?

As mentioned in the introduction, the issue of 'technological stagnancy' related to productivity in services has characterised what we have labelled as the 'Kaldorian' stream of literature, marked by the Baumolian cost disease argument. As opposed to this, the 'knowledge economy' “generation” of contributions has attempted to stretch the concept of technical change in services to advance the opposite argument that services are not stagnant at all and that – instead – they have largely contributed to the productivity resurgence of the US. Both views are - somewhat - reconciled by the diffusion of ICTs and the methodological advances of productivity accounting in services as a result of this, which have significantly increased productivity figures. If one looks at productivity trends in services over time, both views are able to make justice of the empirical evidence. However, in our view, they are both left with some unresolved issues, which we will indicate for future research in Section 5.

3.1) The low productivity curse – Baumol’s cost disease argument

The basic assumption of the unbalanced growth model advanced by Baumol in 1967 is that it’s possible to distinguish between two kinds of economic activities: the ones with high productivity (the so called “progressive” sector) and the ones with low productivity (the so called “non progressive” or “stagnant” sector).
He argues that this division is not the product of chance or history, but it’s the result of the technological inner structure of each activity. The two kinds of activities make a different use of labour: while for the progressive sector labour is an input, for the stagnant sector labour is an end in itself. This characterization makes easy to identify

broadly the progressive sector with the manufacturing sector and the stagnant sector with the service one.

To construct his model, Baumol (1967) adds others assumptions to this basic one, specifically that labour cost is the only cost considered, that wages and their variations are the same in the two sectors and finally that nominal wages rise accordingly to the output per worker of the sector where productivity increases.

Given these assumptions, the model derives several implications.

The first and most important is that, while the unit cost of the growing productivity sector will remain constant, the one of the stagnant productivity sector will increase indefinitely, causing what has become known as the "cost disease" of the service sector. The logic behind this result is quite simple: given the fact that wages increase according to productivity increases, the growth of productivity in the progressive sector generates an increase in wages also in the non-progressive sector (given the assumption that wages increases are negotiated at the national level and are applied at the whole economy). The rise of wage without a correspondent rise of productivity (in the non-progressive sector) gives origin to a rise in the unit cost per output (Baumol, 1967, pg. 418).

The second implication of the model is that non progressive activities whose demand is highly price elastic will experience a tendency for their output to decline and, eventually, to fade away. The reason of this is clear once we considered that the cost increase will translate in a price increase and the supposed high elasticity of the demand implies a huge contraction of the quantity requested by the market (Baumol, 1967, pg. 418).

The third conclusion drawn from the model is that, in the hypothesis of holding constant the ratio of the outputs of the two sectors, an increasing amount of labour force should be transferred from the progressive to the stagnant sector, with the amount of labour in the former tending toward zero (Baumol, 1967, pg. 419).

The fourth and final implication of the unbalanced growth model is that if we try to achieve a balanced growth then we will have a relative decrease of the rate of growth of the economy compared to the one of the labour force. This implies that, if we have constant productivity in one sector and constant amount of labour overall, then our economy's growth rate is bounded to asymptotically tend toward zero (Baumol, 1967, pg. 419).

To sum up, if we hold the assumption made by the model and the identification of the service sector as the non-progressive one, we should expect a stable and inevitable cost increase in this sector coupled with a decline of its output and an increase in its labour force, all of this leading to a zero growth economy.

In Baumol’s original contribution, this phenomenon can be counted among those “economic forces so powerful that they constantly break through all barriers erected for their suppression” (1967, pg. 415).

The main assumption of the model - the division of the economy in two sectors and the identification of the service sector with the non-progressive one - has been from the outset one of the most criticized points. Baumol has revised his original formulation (Baumol *et al.*, 1985) introducing a third sector called “asymptotically stagnant”, a sector between the productive and non-productive one, in which we can find some service activities (like data processing and TV broadcasting) that with time is bounded to follow the same path of the non-productive one. So, also with the introduction of this intermediate sector, the cost disease still afflicts the service sector.

To examine the debate on Baumol’s original idea - and more generally on the economic implication of tertiarization of the economy - is beyond the scope of this paper (for a recent discussion see Lorentz and Savona, 2008). What is important to stress in this context is that the argument of inner technical backwardness as main reason for low productivity in the service sector is deeply established in the economic literature.

But are productivity level and growth rates in the service sector actually low? According to a recent waves of empirical works on productivity (see, among others Bosworth and Triplett, 2007 and Inklaar *et al.*,2008), this is not actually the case, at least in the US. They look inside the data on productivity of the last decades, finding an increase in productivity growth in the US starting from 1995, compared to a productivity slowdown in EU in the same period. They explain this difference mainly with the diverse role of market services in the two economies. So it appears that services, instead of being a break on productivity growth for their supposed inner technical characteristics, are actually the engine that push it up in the US and the reason of the increasing productivity gap between US an UE. This point deserves a more detailed exploration.

3.2) The productivity gap: has Baumol's disease been cured?

Baumol's revised model (Baumol *et al.*, 1985) claims that services are affected by a cost disease and supports this argument on the basis of empirical analysis of the productivity slowdown in the US economy from 1973 on. A productivity slowdown has actually characterized the US economy in the seventies and eighties (as pointed out by Griliches, 1992) and economists have tried to explain it, pointing the finger at the service sector (as we have seen in the previous section). The attempts to explain the slowdown went on until a new event occurred: productivity started to growth, as pick up by Bosworth and Triplett (2007). In their own words "the post-1973 puzzle was never resolved, just abandoned by economists when they were confronted with a new problem – the acceleration of US productivity growth after about 1995" (Bosworth and Triplett , 2007, pg. 413).

What is the reason of this growth? According to the data, this increase can be mainly attributed to the growth of productivity in the market service sector, most likely linked to the diffusion of ICTs relatively higher in services than in the manufacturing sector. So is the main suspect for the previous productivity slowdown now the principal responsible for the recorded increase? On the basis of which empirical evidence? And why is this true for the US and not for the EU economy?

Let's try to answer these question one by one, starting with the issue of data.

3.2.1) The new database on productivity: new BEA and EU KLEM dataset

As mentioned in the introduction, Griliches (1992) noticed that one of the possible reason for the detected low productivity in service sector could have been the mis-measurement of the phenomenon. Referring to the statistics on productivity collected by the US Bureau of Economic Analysis (BEA) at the industry level, he identified several problematic aspect of the actual (at that time) process of data collection, among them the issue of measuring the output of some service sectors by means of the inputs used in the production process (setting the productivity increase to zero by definition, as a matter of fact) or the problematic procedure of the double deflation (Griliches, 1992, pg 8).

Since his observations, several improvements have been achieved in the data collection of BEA, many of them along the line proposed by Griliches, as for example the inclusion among the inputs of capital services from diverse typology of assets, with separate measure for ICT capital services and deflated intermediate inputs (Bosworth and Triplett, 2007, pg 415).

Also, at the European level a new dataset at the industry level has been collected, to perform improved empirical analysis on productivity: the EU KLEMS database. This dataset includes data from 25 EU member states[50] from 1970 to 2005, with a different coverage from country to country (for a full description see Timmer, *et al.*, 2007; O'Mahony and Timmer, 2009). The dataset is constructed in line with the growth accounting framework and decomposes the growth of gross output in eight components: intermediate energy inputs, intermediate material inputs, intermediate service inputs, ICT capital, non-ICT capital, labour composition, hours worked and technical change.

Using these two new sources of data, a new wave of empirical work has been able to prove that the increase of productivity in the US from 1995 on was mainly to be attributed to the market service sector and that the actual productivity gap between US and EU is also due to differences of the service sectors in the two economies. Let’s have a closer look to these results, starting from the latter, I.e.the widening productivity gap between Europe and the United States.

3.2.2) The productivity gap between EU and US in historical perspective

A series of recent contributions (Inklaar, *et al.*, 2008; Van Ark, *et al.*, 2008; Timmer, *et al.*, 2011) have reconstructed the historical differences in the productivity trend between EU economies and the US, using the EU KLEM database to investigate the causes of the patterns observed in the last decades.

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[50] Actually also data on US an Japan are included in the dataset, no data for Bulgaria and Romania are present

Three distinct periods in the trend of EU-US productivity have been identified.

The first one, from the aftermath of World War II to 1973, was characterized by "the typical catching-up pattern, based on imitation and adaptation of foreign technology, coupled with strong investment and supporting institutions" (Timmer, *et al.*, 2011, pg 4).

The second period, from 1973 to 1995, has registered a slowdown in productivity and economic growth both in EU an US, but the distance in output and per capita income levels kept reducing and EU had also a relative faster productivity growth (although slower than the one in the previous period). The relative increase in EU productivity of this period was mainly due to a decrease in labour force participation rate coupled with the reduction in working hours per person employed. This was a consequence of the prevalent labour market institutions in EU countries, characterized by a considerable level of rigidity which in turn led to increasing labour cost. The other side of the decline in labour input was an increase in capital intensity.

In the third and last period, from 1995 to 2007, while EU productivity has continued to decrease, in the US we have registered a steady and remarkable increase. EU productivity fell down from an average annual labour productivity of 2.7 per cent in the 1973-1995 period to a 1.5 per cent in the following 1995-2007 phase, while for the US we detected an increase from an annual average 1.3 to 2.1 per cent in the same time span (Timmer, *et al.*, 2011, pg 8).

Before turning in the next section to the possible explanations of US productivity growth in the period 1995-2007 and of the widening gap with the EU economy, it's interesting to notice that the different trends in productivity in the two economies went on also during the period 2007-2009, which are the first years of the recent (and still on-going) economic crises.

In particular, while EU showed the usual pro-cyclical pattern in labour productivity, in the US there was an unusual anti-cyclical trend, with labour productivity growing at an average 1.6 per cent per year in 2007-2009 period, compared to an yearly average of -0.7 per cent in EU in the same period (Timmer, *et al.*, 2011, pg 9)

Also during the first years of the recent recession, the productivity gap between US and EU appears to be constantly widening. What could it be the reason of this gap?

3.2.3) The role of market services in the productivity growth

Using the BEA dataset, combined with data from the Bureau of Labour Statistics (BLS), Bosworth and Triplett (2007) estimated labour productivity and multifactor productivity at different level of sectoral aggregation (1 and 2 digits). For the labour productivity (LP), they estimated at sector level an annual growth of 2.6 per cent in the period 1995-2001, while the annual growth in the good-producing sector in the same period was of 2.3 per cent. More interestingly, the change of LP from 1987-1995 period to the 1995-2001 was 1.8 per cent in the service sector, while in the manufacturing one was 0.5 per cent.

For the multifactor productivity (MFP), the annual growth in the service sector in the period 1995-2001 also exceeded the one registered in the manufacturing one (1.5 against 1.3 per cent) and the acceleration comparing with the period 1987-1995 is also more impressive, with an increase of 1.1 per cent point for the service sector and only 0.1 for the manufacturing one (Bosworth and Triplett, 2007, pg. 418).

Looking at the data at industry level for both LP and MFP, not surprisingly in both sectors we find a disparity of trends across different industries, with some showing high LP and MFP growth and others displaying lower levels.

Still, at the aggregate level, the picture is quite clear, with a net increase in LP and MFP in the service sector which leads Triplett and Bosworth to affirm that "Baumol's disease has been cured" (2003, pg 23).

But what's the source of this productivity increase? According to Jorgenson, *et al.* (2008), we can identify two distinct sources of it in the period 1995-2004. From 1995 to 2000, the growth of productivity was led by ICT producing sectors and by the increasing use of ICT equipment in all the sectors of the economy (with a capital deepening effect). Starting from the year 2000, "the sources of productivity growth have shifted as total factor productivity growth outside of the production of information technology increased " (Jorgenson, *et al.* , 2008, pg. 4).

So if this is true, the EU productivity slowdown (compared to the US) can be due or to a minor production/use of ICT equipment or to a lower multifactor productivity, which can be interpret as a lower efficiency in the use of inputs in the productive process.

In two different papers based on the EU KLEM dataset, Van Ark, *et al.* (2008) and Timmer, *et al.* (2011) decompose the growth in labour productivity and find that the major driver of the difference between US and EU (and actually also among EU countries) is the difference in multifactor productivity, especially in the market service sector. The difference in multifactor productivity in the market service sector was also found as major explanation of the difference in labour productivity in seven advanced economies in a previous work of the same authors done using a different database (see Inklaar, *et al.*, 2007).

If we consider this explanation convincing, the difference in multifactor productivity in the service sector is the main responsible of the EU-US productivity gap. But what is exactly multifactor productivity? And what does it measure?

In a neoclassical context, the multifactor productivity (or total factor productivity) is a residual measure that account for the variation in output growth after having discounted the contribution of all the inputs used in the production process. In this sense, it can be interpreted as a measure of disembodied technical change and of the efficiency of the production process itself.

However, as a residual measure, it actually takes into account a series of other effects, such as the impact of organizational and institutional modifications, the changes in the returns to scale, the effects of externalities and unmeasured inputs and, finally, it includes also any measurement errors (see Inklaar, *et al.*, 2008, pg 148).

All in all, the fact that the main reason behind the EU-US gap in productivity growth has been imputed to differences in multi-factor productivity is an implicit admission of 'our ignorance' [51] and that – as anticipated above - both streams of literature are substantially left with unresolved issues, both from a conceptual and a methodological point of view.

Anyway, what is important to stress is that the recent progresses in the field of productivity studies have shown that the service sector is not unavoidably condemned to low productivity by its inner technical nature, although much work is still needed to

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[51] Rephrasing Abramovitz (1956, pg 11) we can say that "since we know little about the causes of productivity increase, the indicated importance of this element (multifactor productivity) may be taken to be some sort of measure of our ignorance about the causes of economic growth"

make sense of the empirical evidence, once scholars have decided that we can trust the measurement issues behind the production of these figures.

4) Does productivity always matter?

The empirical literature illustrated in Section 3 has relied on the methodological tools revised in Section 2. So far we have illustrated streams of contributions which have developed within the boundaries of traditional methods of measuring productivity and have not radically questioned the use of them in services, even when scholars are aware of the drawbacks of extending traditional measures to services. What are the possible ways out? How to convincingly extend tradition tools to services? Alternatively, do we dispose of a theoretical framework and methodological apparatus which allow us to propose an alternative way of measuring productivity in services? But first of all, are we able to claim that the concept of productivity itself matter for services the same way than in the manufacturing sector or we rather need new indicators to assess performance in services? Below we briefly review some of the contributions taking these different stands, before proposing our own.

4.1) The "no need for new tools or new concepts" position

An interesting position in the debate on how to measure productivity in the service sector is the one taken by Baumol, *et al.* (1989). They first distinguish between three different notions of productivity: productivity as growth in the productive capacity, welfare productivity and gross productivity.

If we think of productivity as growth in the productive capacity, then productivity increases when the productive capacity of an economy raise or alternatively – if we think in term of productivity frontiers – when the productivity frontier of an economy moves outwards due to technical change.

The notion of productivity as welfare productivity implies that we have an increase when consumer and producer's welfare per unit of input augment and take into account not just technical change but also issues regarding allocative efficiency and quality change.

The third notion – productivity as gross productivity – implies to measure productivity through a simple ratio of output over input with no attempt to adjust for quality change. After having clarified this distinction, Baumol *et al.* (1989, pg. 235) argue that each one of the three interpretation of the concept of productivity has its valid and meaningful use.

For the service sector, instead of the more comprehensive concept of welfare productivity - that takes into account also quality changes - they suggest to use the concept of gross productivity.

This is somehow surprising in the light of what we have seen so far about mis-measurement problems linked to quality change in the service sector (see section 2.3). Baumol et al. (1989) argue that the reason why we should be interested in gross productivity rather than a measure adjusted for quality is that "gross productivity is the primary determinant of the budgets, costs and prices of the product in question" (Baumol et al , 1989, pg 242). They consider the case of high education, where the cost per student is the reciprocal of the student/teacher-time ratio (which is a measure of gross productivity) times the average hourly faculty salary. If we assume that wage dynamics are determined outside the university, the only way the administration can affect cost is by increasing gross productivity.

They go even further in their reasoning, suggesting that there are "some application of productivity measurement for which it is simply wrong to take quality change into account" (Baumol et al , 1989, pg. 242). Thus this line of reasoning suggests that most of the time there is no need to worry about quality changes and that gross measure of productivity can be quite accurate, especially in the service sector. To our knowledge, this view is in minority position in the literature of productivity in services, where it is far more common to call for adjustments of productivity measures to deal with services' characteristics.

4.2) The “tool readjustment” position

A more significant part of the literature on service sector productivity is focused on adapting or redefining the analytical tools developed to measure productivity in manufacturing in order to take account of the specificities of services.

In this direction goes the attempt to compute a productivity index for services that takes into account quality changes. This can be done directly (as suggested, among others, by Vourinen et al 1998) by including some direct measure of quality in the gross productivity index, that becomes the ratio between a measure of output volume times a measure of output quality and a measure of input volume times a measure of input quality. The problem in this case is to find a reliable direct measure of quality for output and input. Quality changes can be also considered in an indirect way through the use of hedonic prices, as done in the ICT sector (see section 2.3.4)

Also non parametric methods –and in particular data envelopment analysis (see section 2.3.2) - are adopted in the analysis on service sector productivity. Their ability to deal with multiple inputs and outputs without requiring a predetermined functional form of the production function is a feature that make them suitable to be used in the service sector (for a recent review of the application of DEA methods in the service sector see, for example, Avkiran 2011)

A slightly different approach is the one of Grönroos and Ojasalo (2004), who develop a specific model for services in which productivity is a function of internal efficiency, external efficiency and capacity efficiency. Internal efficiency is defined as the ability of convert inputs into outputs inside the firm while external efficiency refers to how the quality of the service is perceive outside the firm. Capacity efficiency refers to the ability of the firm to deal with changes in demand, given the fact that services are not stockable. Considering these three dimensions of efficiency, they end up with a general formula to calculate productivity in services as the ratio between revenues from a given services over cost of producing this services or, in more general terms, total revenues over total costs (Grönroos and Ojasalo, 2004, pg. 421). The index increases if revenues increase due to an increase of quality or if cost decrease due to a reduction of inputs. However, using revenues allow also to take into account the fact that a reduction of input can be perceived as a reduction of quality, causing a reduction of revenue and so a

reduction in the value of the index (as long as revenue reduction is greater than cost reduction)[52]. As Grönroos and Ojasalo (2004, pg 421) themselves point out, this kind of measure is not without problems, giving that revenues are not always an accurate measure of output and can be a bad measure of quality in non-competitive markets.
All in all, it is worth noticing that there is also a different perspective to the issue of productivity in services that can be somehow be considered part of what we have called the "tool readjustment" position. This point of view reverses in a sense the perspective: instead of adjusting productivity measurement tool to consider services' specificities, we reinterpret services output to make it more similar to manufacturing so that we can use the standard productivity measures. With "industrialized" services, we can compute productivity as we do in the manufacturing sector with no much of a methodological or mis-measurement problems (for a recent example of this kind of view see Hartigh and Zegveld, 2011).

4.3) The "no need for productivity in services" position

A more radical position is the one expressed by Djellal and Gallouj (2008 and 2010). Starting from the distinction suggested by Gadrey (1988) between output and outcome and then analysing the implications for the concept of productivity in the service sector, they call for the need of a multi-criteria evaluation in which productivity has a role but has lost its monopolistic power within measures of performance
What they argued is if the concept of productivity itself is still essential in a post-fordist economy and they propose to move from the idea of measurement to the idea of evaluation. Their suggestion is to use valuation convention to define output and compute performance indexes. In order to do so we have to consider a number of different "worlds and value systems" (Djellal and Gallouj, 2008, pg. 51).
In their proposed new way of defining and evaluating services, they consider different justificatory criteria, corresponding to six different worlds: industrial and technical world, market and financial world, relational or domestic world, civic world, world of innovation, world of reputation (for a more detailed description see Djellal and Gallouj,

[52] See section 2.2.3.3 for a description of this mechanism of perceived bad quality – reduction of revenue.

2008, pg. 53). Performance is then assessed with respect to the output or direct product and the outcome or indirect product which have to be taken into account respectively in the short and long term.

Their approach link a variety of generic performance to a variety of generic outputs considered in terms of volume and quality. All in all, this approach puts aside the concept of productivity and uses a multi-criteria evaluation method to assess the performances in the service sector. As intriguing as this perspective can be, it would require a huge amount of data to be operationalized. Virtually the lack of possibility to compare performances across space (different organization are likely to have different value systems) and time (the same organization can have a certain value system at time t_1 and a different one at time t_2) makes this perspective very appealing though poorly operational.

5) A proposed way forward

The existing literature has explored several different directions which depart from the conception offered by Adam Smith on “unproductive labour”[53] despite an initial predominance of the Kaldorian/Baumolian view of a “tertiarisation curse” in terms of productivity growth, superseded by a subsequent 'knowledge economy” view which instead focuses on services as the main actors of the recent US productivity resurgence.

In practice, methods to calculate productivity employ a mixture of methods differing by sector for measuring service output – 1) inputs are taken to be outputs, 2) rough deflation in which expenditure is deflated by an index not specific to the sector of service output, 3) physical measures of services delivered (e.g. letters delivered), and 4) expenditures divided by a sector specific price index derived from expenditure surveys (as in the case of hair dressing) or from cost estimates. (Oulton 1999). Each of these measures is an approximation which aims at treating service output in a

[53] Unproductive labour does not fix or realise itself in any particular subject or vendible commodity. His services generally perish in the very instant of their performance, and seldom leave any trace of value behind them, for which an equal quantity of services could afterwards be procured” (Smith (1998) [1776] : Book II, first para. of Ch. III)

comparable way to what is done with industries either with relative homogeneous outputs. This subterfuge was pointed out as a major drawback in services output (and productivity) measurement by Griliches twenty years ago (Griliches, 1992).

In the presence of technical change, these issues are even more severe, as technical change might lead to a significant increase in the heterogeneity of outputs and – along the same lines – might translate into a variety of input-saving processes, depending on which input is saved and whether an input re-allocation within the production process is at work. From both an economic and innovation theory perspective, therefore, the puzzle is both conceptual and methodological: to what extent changes in quality of the inputs or outputs or both represent innovations leading to productivity increases? How do we account for innovativeness in terms of quality change and how do we embody this into measurement of productivity? What kind of relation can be established between traditional indicators of product and process innovation and, respectively, for quality-enhancing productivity and input saving productivity?

In order for advances to be made in both these inter-linked domains of productivity and innovation in services, a better theoretical conception of service 'production' and output definition is needed.

What is proposed as an advancement in both economic and innovation theory is to further develop the foundations of service production along the lines suggested by (Gallouj and Weinstein 1997) and (Gallouj and Savona 2009) who reprise the Lancasterian (and post-Lancasterian) approach to define output. According to the characteristics-based approach in its original formulation (Lancaster, 1966) and in those which followed (Saviotti and Metcalfe, 1984; Gallouj and Weinstein, 1997; Gadrey, 2000; Gallouj and Savona, 2009), output is represented by a set of vectors of characteristics and competences, linked to each other. Vectors of characteristics include technical ones, service ones (or, interestingly, 'final users' value') and competences, both of supplier and user.

The Lancasterian offers[54] an interesting conceptual platform which allows advance in both the output definition of services and on the effect of technical change on it in terms of various forms of innovation. Also, it allows including the role of customers in

[54] See on this point also chapter II, section 3.3

the innovation process – this latter having been claimed to be more important in services than in other sectors, due to the co-terminality between delivery and consumption. Most importantly, looking at an output in terms of characteristics and competences makes us go beyond the market and non-market contexts in which outputs may be delivered to consumers.

Most importantly, besides the urge of reworking output definition - we believe that a similar effort should be conducted on the input side. Productivity increases might well come from input-saving innovation – mostly associated to process innovation. In the case of services – as well as in goods – we argue that input-saving productivity increases are to be considered in terms of substitution between different intermediate inputs, including energy and time along with labour and capital. This would allow us to "weight" from a welfare perspective the type of input-saving productivity enhancements and rank the specific input-saving process in terms of social desirability. For instance, energy saving (process) innovations might well be more desirable than labour-saving (process) innovation from a welfare perspective. Or, rather, deskilling innovation are less favourable than up-skilling innovation, should we be able to choose between two different (and seemingly equivalent) labour-saving productivity increases. Along the same lines, time-saving productivity enhancements have to be considered within an innovation framework and assessed against capital-deepening or capital-widening related productivity increases.

Fig 1.A: Relative use of inputs (measured in volume indices, 1995 = 100) in the UK 1970-2005_Total Indusitres

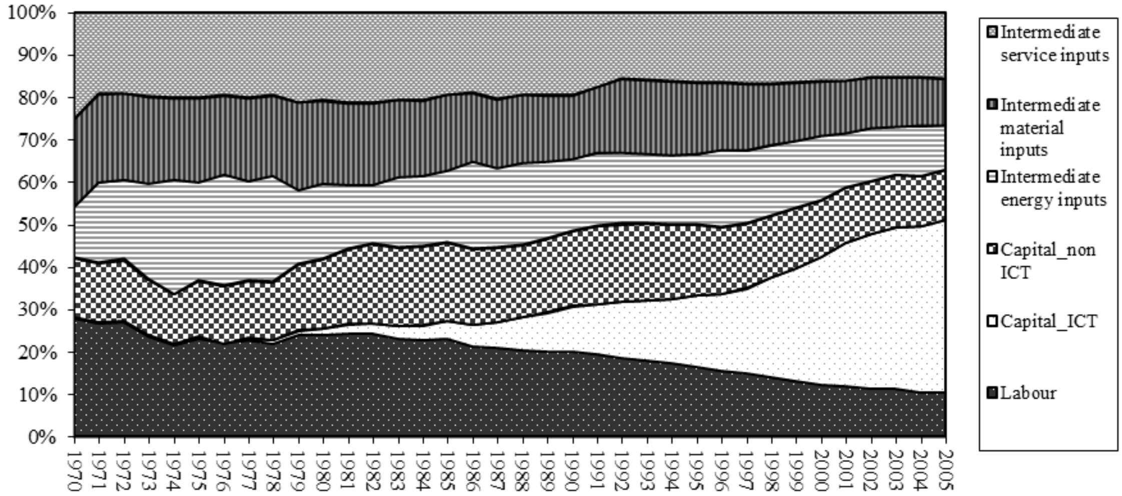


Fig 1.B: Relative use of inputs (measured in volume indices, 1995 = 100) in the UK 1970-2005_Total Manufacturing, excluding Electrical

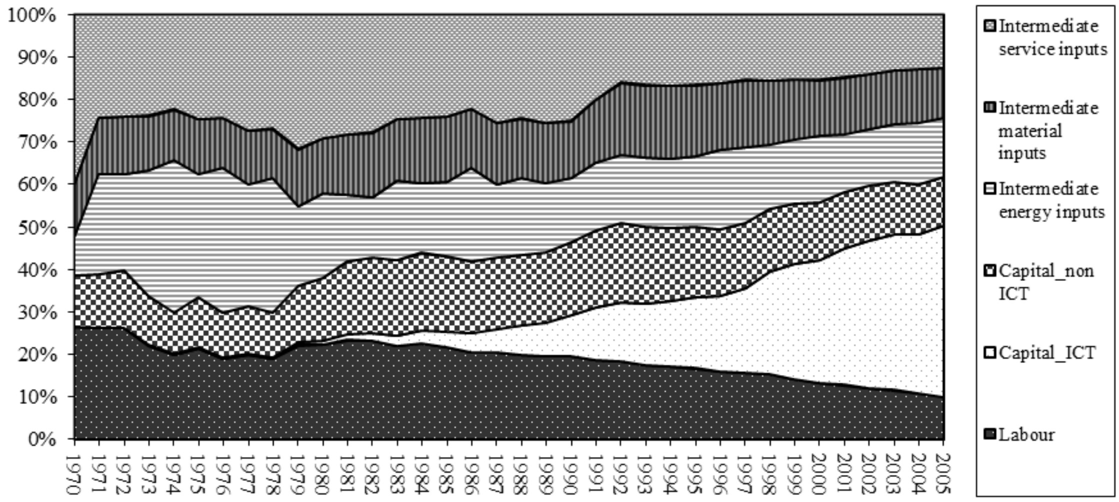
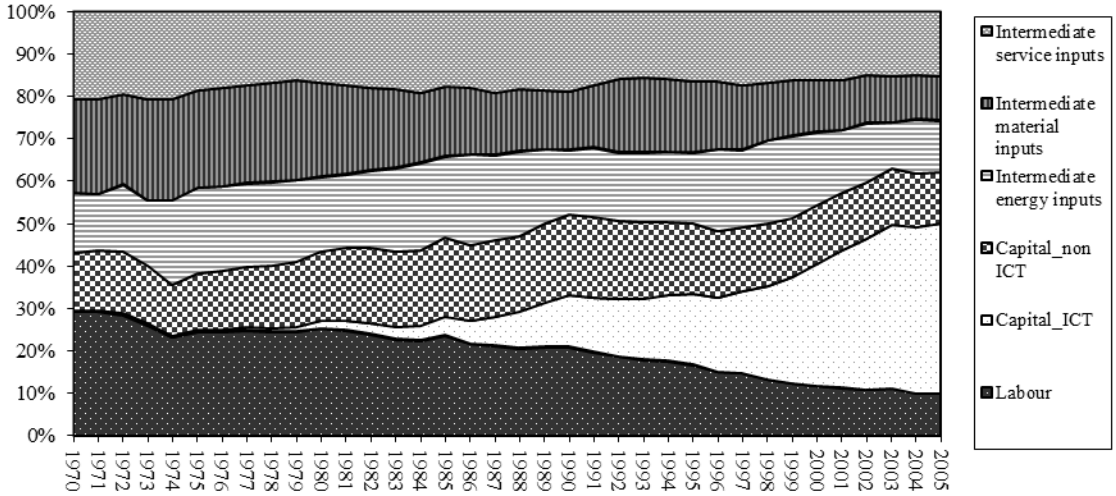


Fig 1.C: Relative use of inputs (measured in volume indices, 1995 = 100) in the UK 1970-2005_Market Services, excluding Post and Telecommunications



For example, figures 1.A 1.B and 1.C above show the trends of input using changes across sectors over time in the UK, taking into account a wider variety of intermediate inputs. Using data from the EU KLEM database[55], these figures show the relative inputs' use for the total economy, the manufacturing sector (excluding electrical)[56] and

[55] See section 3.2.1
[56] In this sector we have: "food products, beverages and tobacco"; "textiles, textile products, leather and footwear"; "manufacturing nec; recycling"; "wood and products of wood and cork"; "pulp, paper, paper

the market services sector (excluding post and telecommunications)[57]. The inputs considered are: “labour”; “capital ICT”; “capital non ICT”; “intermediate energy inputs”; “intermediate material inputs”; and “intermediate service inputs”. All inputs are measured in volume terms (base year 1995), so being 100 the sum of all the inputs entering in the production process, we can look at the trend in their relative use over a 35 years period (1970-2005). Clearly, the most relevant trend is the change in the production recipe due to the introduction and diffusion of ICT capital, with a relative reduction in the use of labour. This is true also if we look separately at the manufacturing and the service sectors.

This seems to us a key starting point to re-assess productivity increases, all the more so, as this has a tremendous relevance from a policy perspective within the recent debate on EU smart and inclusive growth, that is in economies which are for their largest shares service economies.

6) Conclusion

This paper has attempted to systematise the literature on productivity in services, by reviewing conceptualisation, measurement methods and empirical trends on productivity in services. We have singled out three issues which seem relevant in this context and selectively reviewed the literature according to whether it could provide us with convincing answers to these: (i) the appropriateness of the standard concept and measurement of productivity for services; (ii) the account of technical change and innovation in both the conceptualisation and measurement of productivity in services; (iii) the proposal of new, better ways to conceptualise and measure productivity in

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products, printing and publishing”; “Coke, refined petroleum products and nuclear fuel”; “Chemicals and chemical products”; “Rubber and plastics products”; “Other non-metallic mineral products”; “Basic metals and fabricated metal products”; “machinery, nec”; and “transport equipment”.

[57] In this sector we have: “trade”; “sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel”; “wholesale trade and commission trade, except of motor vehicles and motorcycles”; “retail trade, except of motor vehicles and motorcycles; repair of household goods”; “transport and storage”; “financial intermediation”; “renting of m&eq and other business activities”; “hotels and restaurants”; “other community, social and personal services”;
and “private households with employed persons”.

services, should traditional indicators of productivity be found misleading or mis-representing when applied to services.

What we have found is that most of the literature have for long time studied services using analytical and empirical tools developed for analysis in the manufacturing sector, often without tailoring them on the peculiarities of services. The use of productivity as a measure of economic performance is one of the most outstanding examples of this. We have seen how the characteristics of the output in the service sector have affected the initial estimates of productivity, guiding to the conclusion of the natural technological backwardness if services.

Only with improved conceptualization and more accurate data, evidences have emerged supporting the view of services not as an unproductive burden for the economic, but as a potential driver of economic growth.

The road ahead is still long, here we suggest two possible directions for further research. The first one is a better conceptualization of the output of services along the line of the characteristics-based approach, mostly along the line of a possible empirical implementation of it.

The second largely unexplored direction regards a deeper understanding of inputs in their connection with productivity. Studying the input-saving and input-substitution effects of changes in productivity in the service sector, especially in a word of increasing pressure on “new” scarce resources such as time and - to a certain extent – energy, is an important goal for future analysis.

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IV. An empirical attempt of integrated taxonomy: a cluster analysis of Italian innovative firms

1) Introduction

The aim of this chapter is to build an empirical taxonomy to classify Italian innovative firms using CIS-2008. To do so, we first have to agree on what an "innovative firm" is.
In the CIS survey framework, an "innovative" firm is the one introducing (or at least trying to) a new product and/or process innovation in the previous three years.
But if we adopt a Schumpeterian point of view, then an innovative firm is also the one introducing an organizational or a marketing innovation[58].
In this chapter we decide to follow the Schumpeterian concept of innovation to decide what an innovative firm is and to combine it with the original spirit of Pavitt's famous taxonomy (1984), which was "to go beyond explanations of sectoral patterns of production of innovations simply in term of sectoral industrial structure" (pg. 352).
In fact our work is an attempt to "go beyond" the strict sectoral industrial structure in search of cross-sectoral innovation patterns according to a wider concept of innovation (i.e. not restricted to the narrow technological dimension).
What we do in this chapter is to look at the pattern emerging from the different kind of innovation activities performed by Italian firms and see if this pattern is to some extent overlapping with the traditional sectoral classification of economic activity.
In other words, we want to see if particular model of innovation are aligned along the traditional division line between manufacturing and service sector.
To do so, we will use the information about the different types of innovation activities performed by Italian firms and combine them together, adding data about the structure of the firm, to derive an integrated empirical taxonomy of innovative behaviours.
With "integrated" we mean a taxonomy that consider in a single theoretical framework all the firm , without distinguishing for sector of economic activity. The "empiric" character derives from the fact that our taxonomy will be built using cluster analysis,

[58] See the discussion on this point made in chapter II session 5

and so will be "suggested by the natural grouping of data themselves" (Hair, *et al.*, 2010, pg. 508)

A "taxonomy" is an attempt to "to create some initial order out of the chaos that always characterises empirical research in new fields" (Sundbo, 2009, pg. 432). Extending the definition of "innovative firms" beyond the traditional narrow technological scope augment the data requirement for our taxonomy exercise. Unfortunately, the new edition of CIS survey (2008), although has pushed to a further extent the already ongoing process of "de manufacturization", is still focused on those firm that we have defined "innovative in a narrow technological way". In fact, CIS 2008 has some detailed information about, for example, the sources of innovation input, the resources spent in the innovation process and the possible cooperation with other economic agents only for those firm introducing (or trying to) a new product and/or a process innovation. This make the level of deepening of our taxonomy not matching the level of its width. However, some information on the goals of the introduction of the innovation are available for all the firms "innovative in a Schumpeterian way". These information – among others - will be used to profile the cluster obtained from the analysis of the innovation activities performed.

The rest of the chapter is organised as follow: section 2 makes a review of the major taxonomies of innovative firms, with a particular focus on those built for the service sector and those derived from data on Italian firms; section 3 describes data and methodology used; section 4 provides an exploratory preliminary analysis of the data set, showing some descriptive statistics; while section 5 reports the results of the cluster analysis performed; and finally session 6 concludes.

2) Taxonomies of innovative firms in the service sector: an overview

"Taxonomies are meant to classify phenomena with the aim of maximisirig the differences among groups. While, for example, "classifications" are often highly disaggregated, both in natural and social sciences, a "taxonomy" is considered useful, if it is able to reduce the complexity of the population studied into easily recallable macro-classes (Archibugi, 2001, pg 417)"

In this section we revise (without pretending to be exhaustive) some of the attempts to derive an empirical taxonomy of innovative firms. In particular, we will focus our attention on three kinds of taxonomies: those regarding only the service sector; those treating jointly manufacturing and service firms; and finally, taxonomies build from dataset on Italian firms (just manufacturing, just service or both together).

Any review of empirical taxonomy of innovative firms – whether they be in the manufacturing or in the service sector – must undoubtedly start with the work of Keith Pavitt.

2.1) The mother of all taxonomies: Pavitt's sectoral patterns of technical change

In his path-breaking article, Pavitt (1984) proposed a taxonomy of innovative firms that is arguably one of the most influential taxonomies in innovation studies today. With the purpose of "describ[ing] and try[ing] to explain similarities and differences among sectors in the source, nature and impact of innovations" (1984, pg. 343), Pavitt used the data from the SPRU to build a classification of innovative firms. Having the firm as a basic unit of analysis, he explored data and classified firms according to the following dimensions: the sources of main knowledge inputs; the sectors in which innovation were produced and used; and the size and principal economic activity of the innovative firms (1984, pg. 345) Four different types of innovative firms were identified: "supplier dominated", "scale intensive", "specialised supplier"[59] and "science based" firms. In this first version of Pavitt's taxonomy there is very little room for the service sector. Service firms are included in the "supplier dominated" group, which is characterized by small firms with limited in-house R&D, interested in cutting costs and in which "most innovations come from suppliers of equipment and materials" (Pavitt, 1984, pg 356)[60]. This description closely matches the dominant image of the service sector as "simple recipient of innovation"[61]. This result could also be partly due to the characteristics of the data used by Pavitt for deriving his taxonomy. In the SPRU database, out of the 4378 innovations successfully commercialised in the UK between 1945 and 1983, only

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[59] "Scale intensive" and "specialised supplier" are actually two parts of a single group of firms that Pavitt calls "production intensive"

[60] For a detailed description of all the four different typologies see Pavitt's original article, 1984, pp.356-364.

[61] See chapter II section 2 on this point

around 343 were made by firms operating mainly in the non-manufacturing sectors (Pavitt *et al.*, 1989, pg. 85)[62].

In a follow-up of the original contribution, Pavitt *et al* .(1989) added a fifth category to the four listed before This was, to some extent, a response to the criticisms received regarding the inclusion of the all service sector in the supplier dominated group. The "information intensive" category (Pavitt *et al* .,1989, pg. 95) was added as an attempt to address the emerging innovation opportunities generated by the use of ICT in sectors like banking and retailing. However, the bulk of service sector stays confined to the specialised supplier category and Pavitt's taxonomy remains mostly a manufacturing taxonomy.

Pavitt's original taxonomy is the starting point of a strand of literature that tries to derive empirical taxonomies for innovative firms and mainly uses Pavitt's categories as a tool or as a benchmark[63].

Archibugi (2001) highlights five critical areas in the first Pavitt's taxonomy of possible improvements and worthy of additional analyses:

- it does not cover innovative firms;
- it classifies first firms into industries and then in industries into taxonomical categories, instead of classifying firms directly into taxonomical categories;
- it's difficult to accommodate into Pavitt's taxonomy multi-product and multi-technology firms;
- it's applied at firm level but can be applied also at product level;
- it's conceived for the manufacturing sector but can be amended to classify innovations in the service firms.

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[62] Actually Pavitt, *et al*. (1989) report that in their analysis "innovations made by government departments and quasi-public R & D laboratories have been excluded, reducing the sample by 240 innovations (i.e. 5.5% of the total). Of the remainder, 91.7% were made by firms principally in manufacturing"(pg 85.). Using these information and knowing that the total of innovations included in the SPRU database is 4378 (Robson, *et al*., 1988, pg 1), we calculate that 343,4 innovations were made by firms operating mainly in non-manufacturing sectors, i.e. in some of the services' branches.

[63] An example of this is Souitaris (2002), who applies Pavitt's taxonomy to a sample of Greek firms to test differences in the determinants affecting innovation. A more recent article by Castellacci (2009) uses Pavitt's taxonomy, in combination with the concept of national system of innovation, to explore cross-country variability of patterns of innovation.

This last point is the most interesting from our perspective, given that the first attempts to derive a taxonomy of innovative firms in the service sector were actually made amending and reshaping Pavitt's original classification.

2.2) Taxonomies of innovative firms in the service sector

The pioneering efforts of deriving taxonomies in the service sector were hampered by the lack of data on innovation in service firms. Indeed, the taxonomy proposed by Soete and Miozzo in two different contributions (1989, 2001) was first elaborated without resting on solid empirical evidence. While Pavitt started with the observations in the SPRU database to build his taxonomy, Soete and Miozzo began with the categories originally spotted by Pavitt and went on to modify them to accommodate the characteristics of service firms. In their taxonomy, three groups of service sectors are identified: "supplier dominated sectors"; "scale-intensive physical networks sectors and information network sectors"; "science based and specialized supplier sectors".

The first group – supplier dominated firms – is composed mainly by firms in personal, public and social services. This group is similar to its homonym in the Pavitt's taxonomy, so it is characterized by the presence of small firms, with very weak in-house R&D and suppliers as main source of innovation.

In the second group, with the help of ICTs application, we find firms that apply a detailed division of labour on a large scale for delivering highly standardized services with the help of ICTs application. In this class, we have two subgroups: those relying on "physical networks" (like transports and wholesale trade) and those based on "information networks" (like communications and finance).

The latter group – science-based and specialized suppliers sectors – is made by "business services closely linked to R&D, software, and the development and application of information technologies" (Miozzo and Soete, 2001, pg 162).

The work of Sundbo and Gallouj (2000) represents a different approach to service innovation taxonomy. Instead of reshaping and reframing Pavitt's taxonomy in a service-friendly way, they begin by determining the driving forces of innovation in services. They then combine those forces to derive patterns of innovations. The driving factors that they detect are three: "internal factors" (such as the management and strategy of the firm or the employees); and “external factors”, distinguished in “trajectories” – indicating “ideas and logics that are diffused through the social system” (pg. 50) – and “actors” (like competitors, customers and suppliers, for example).

Different combinations of these driving forces give birth to different patterns of innovation in services[64], including technological trajectories but without an exclusive emphasis on them. Using the words of Sundbo and Gallouj (2000):

“compared to Pavitt’s general sectoral taxonomy (1984) or to Soete and Miozzo’s service innovation taxonomy (1989), our model does not focus on technological trajectories alone, but it also take into account several other trajectories: service-professional, managerial, social, and institutional”(pg. 66).

Similar to Sundbo and Gallouj (2000), also den Hertog (2000) identifies five innovation patterns specific for service firms. His taxonomy, which appears almost simple when compared to the more articulated Sundbo and Gallouj’s classification, these patterns emerge from the combination of the relationships among three kinds of actors: suppliers of inputs; the innovative service firm; and the client. Different interactions give rise to different patterns, five of which are identified: “supplier-dominated innovation”; “innovation within services”; “client-led innovation”; “innovation through services”; and “paradigmatic innovation”[65].

Despite the differences, taxonomies by Soete and Miozzo (1989, 2001), Sundbo and Gallouj (2000) and den Hertog (2000) are more theoretical than empirical classifications[66].

The first attempt to replicate the Pavitt’s taxonomy logic – which is starting from the data to derives typologies – in the service sector is probably the one performed by Evangelista (2000)[67].

His empirical taxonomy is based on information regarding the kind of innovation introduced; innovation inputs; sources of information exploited to innovate; and

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[64] Those empirically identified by Sundbo and Gallouj (2000) are: the classical R&D pattern (and industrial pattern of innovation) and its evolution; the service professional pattern; the organised strategic innovation pattern; the entrepreneurial pattern; the artisanal pattern and the network pattern. For a detailed description of them all see Sundbo and Gallouj, 2000, pp 52-60.

[65] A complete description of the five patterns can be found in den Hertog, 2000, pp 500-504.

[66] To be fair, Sundbo and Gallouj (2000) starts from a theoretical perspective and then verifies empirically the typologies actually existing in the service sector. However, this deductive approach is the opposite of the inductive approach used by Pavitt to build its taxonomy.

[67] This work is a deepening of a previous unpublished contribution by Evangelista and Savona (1998)

objectives of the innovation activities (Evangelista, 2000, pg. 185). Relying on data coming from the Italian CIS-2[68] he builds a sectoral taxonomy of innovation in services through the use of factor and cluster analyses. Factor analysis is first performed to reduce the number of variables taken into consideration and extract a limited number of synthetic factors. The three factors extracted are then used in a cluster analysis to identify patterns of innovation in services. The procedure ends up detecting nine clusters, that can be grouped in four broad categories: "technology users"; "S&T-based"; "interactive and IT based"; and "technological consultancy". The first two categories are similar to the supplied dominated and science-based typologies spotted by Pavitt (Evangelista, 2000, pg. 215), while the "interactive and IT based" typology seems a more genuine service trajectory[69]. The main limit of Evangelista's taxonomy (as acknowledge by the author itself) is in the kind of data available. This only covers technological features of innovation and neglects non-technological aspects, which are indeed a fundamental feature of innovation in services[70]

This technique of combining factor analysis to reduce the number of relevant dimensions and then cluster analysis to group similar innovative service firms is used by Hollenstein (2003) in his taxonomy of the Swiss service sector. Relying on firm-level data collected by the Swiss Innovation Survey in 1999, Hollenstein exploits innovation inputs; innovation outputs; and market (both demand and supply sides) indicators to identify five different clusters[71]. The data utilized in Hollenstein's taxonomy arguably has an advantage over Evangelista's: the definition of "innovation" adopted in the Swiss Survey "does not make any direct reference to technology" (2003, pg. 850). Furthermore, there are other indicators explicitly designed to detect non-technological characteristics of innovation. So the data used to profile innovation patterns in the service sector has information that the CIS-2 dataset used by Evangelista does not include. Reflecting on the importance of non-technological aspects of innovation, not

[68] See chapter II section 5 on this point
[69] For a detailed description of all the four different typologies see Evangelista's original article, 2000, pp 211-213.
[70] See chapter II on this point
[71] The five clusters identified are: "science-based high-tech firms with full network integration"; "IT-oriented network integrated developers"; "market-oriented incremental innovators with weak external links"; "cost-oriented process innovation with strong external links along the value chain"; and "low-profile innovators with hardly any external link". For a full explanation of the five clusters' characteristics see Hollenstein's original paper, 2003, pp 852-856.

only in the service sector but also in the manufacturing sector, Hollenstein concludes that the a difference between the two "exists, although it seems to be one of degree rather than of substance. Against this background, it would be sensible to look for innovation model using data covering both sectors" (2003, pg 861). Coincidentally, this is exactly the route taken by a consistent number of recent empirical taxonomies.

2.3) Integrated taxonomies of innovative firms

The attempt of deriving empirical integrated taxonomy, i.e. based on data of manufacturing and service innovative firms jointly considered, is an increasing trend in literature. This are also the results of the changes in attitude towards innovation in the official statistics, as reflected in the changes of the Oslo Manual and of the CIS survey over time[72]. With an increasing availability of data regarding non technological aspects of innovation and of cross-country comparable statistics, an empirical taxonomy based on data of both manufacturing and service firms of different European countries has become feasible. The taxonomies of Castellacci (2008) and Peneder (2010) are in fact two attempts of building empirical classification out of a cross-countries dataset of manufacturing and service innovative firms.

This does not mean that integrated taxonomies regarding a single country (such as Jong and Marsili's 2006 taxonomy of the Netherlands that includes small manufacturing and service firms) or taxonomies focusing only on the service sector innovative firms (e.g. Camacho and Rodriguez, 2008, based on Spanish service sector) are not produced anymore.

de Jong and Marsili's taxonomy (2006) is particularly interesting. They focus their attention on small firms, systematically neglected in taxonomies based on CIS data[73]. They collect data on small firms in Netherlands and perform a cluster analysis to derive a taxonomy. Before cluster analysis, they use principal component analysis to synthesize the relevant variables in their dataset; and after cluster analysis they use a χ^2-test to validate the taxonomy (de Jong and Marsili ,2006, pg 221).

[72] See chapter II section 5 on this point

[73] Firms with less than 10 employees are not included in the CIS sample

The dimensions employed for the taxonomy are from one hand those typically used for classifying large firms (innovative input and output, sources of innovation): and from the other hand peculiar dimensions of small firms (managerial attitude, external orientation and innovation planning).

The result is the individuation of four different groups of firms: "supplier-dominated firms"; "specialised suppliers"; "science-based firms"; and "resources-intensive firms".

The resemblance to Pavitt's categories[74] is not just in the names, but also in the characteristics of the firms of each group[75]. Their findings seem to support the view that services and manufacturing share largely common innovation trajectories, also when it comes to small firms pattern. In other words, their results provide further evidence to support the integrate approach to taxonomy building.

Castellacci (2008) suggests a new taxonomy that merges service and manufacturing in the same framework. This classification is based on the main function of each industrial sector in the overall economic system and on the main innovative model typical of their activity. He criticises Pavitt's model, not for its logic or results but because it is out of date[76].

Using data from the CIS-4 dataset for 22 countries merged with information from the OECD Stan database, Castellacci proposes a two steps taxonomy: first sectors are divided in four main groups according to their principal economic function (providers vs. recipients of good and services); then each group is split in two according to the technological content (knowledge buyers vs. knowledge producers). The four groups identified are: "advanced knowledge providers"; "mass production goods"; "infrastructural services"; and "personal good and services" . Then each of them is divided in two subgroups[77]. The differences between and within groups are tested

[74] The authors stress that they "label the four group of firms to stress the similarities with Pavitt's taxonomy" (de Jong and Marsili ,2006, pg 221)

[75] For a complete description of the four clusters' features see de Jong and Marsili's original paper, 2006, pp 223-224

[76] "Pavitt's model of the linkages between science-based, specialized suppliers, scale-intensive and supplier-dominated industries provides a stylized and powerful description of the core set of industrial sectors that sustained the growth of advanced economies during the Fordist age" (Castellacci,2008, pg. 980).

[77] The "advanced knowledge providers" group is split in "Specialized suppliers" and "Knowledge-intense business services"; in the "mass production goods" class we find "scale- intensive" and "science based" subgroups; "infrastructural services" are divided in "physical infrastructure" and "network infrastructure"; while in the "personal good and services" we have "supplier dominated goods" and

through a parametric and a non-parametric test, finding that "the cross-country distributions of the sub-groups of industries belonging to each of the four sectoral groups differ from each other at conventional statistical levels on several important dimensions" (Castellacci, 2008, pg 988).

Castellacci's taxonomy is more a theoretical taxonomy validated through data than an empirical taxonomy emerging from the data. Moreover, it focuses on sectors rather than each singular firm.

Peneder (2010) instead starts considering the individual firms' characteristics and uses them to derive an empirical taxonomy. He bases his new integrated taxonomy distinguishing firms according to their creative or adaptive behaviours from one side, and differences in the technological regime (regarded as appropriability conditions, opportunities and knowledge's cumulativeness) in which the firm operates from the other side (pg 324). He applies a cluster analysis using data of 78.000 firms of 22 European countries included in the CIS-3 survey. Five groups of innovative firms are identified according to the degree of innovation intensity ("high"; "intermediate-to-high"; "intermediate"; "intermediate-to-low"; and "low")[78].Having a dataset with 22 different countries (clustered in five broad groups according to geographical proximity), Peneder tests also his taxonomy in different groups of countries and the taxonomy has proven its' consistency.

The most interesting features of Pender's classification is that "the sectors are not classified according to an industry average, but by the distribution of diverse firm types" (2010, pg. 333). This allows to account for inter-sectoral and intra-sectoral differences of innovative intensity at the same time, providing a way to cope with the presence of innovative firms in low innovative sectors and vice versa. Consequently, Peneder's taxonomy is an integrated taxonomy for two reasons. Firstly because it handles in the same theoretical framework manufacturing and service firms (as that of Castellacci, 2008); secondly because, by being applied directly to firms instead of industrial sectors, it allows innovative firms to be grouped together irrespectively of the particular industrial sector to which they belong to. In this respect, the use of cluster

"supplier dominated services". See Castellacci (2008, pp 983-989) for a specific description of each one of them.

[78] For the description of each cluster see Peneder, 2010, pg 329.

analysis is particularly appropriate because it "has the advantage of letting the data to draw the boundaries between sector groups"(Peneder, 2010, pg. 333).

2.4) Taxonomies of Italian innovative firms

Most of the taxonomies regarding innovative Italian firms have focused their attention on the manufacturing sector. A first wave of relevant articles was published at the beginning of the nineties. This was probably due to the availability of data deriving from the initial attempts of conducting innovation surveys at national level carried out by the Italian National Institute of Statistics (ISTAT) and the National Research Council of Italy (CNR) during the eighties (see Archibugi *et al.*, 1991, Cesaratto *et al.*, 1991). The focus of the first surveys was technological innovation and carried out in the manufacturing sector, so also the taxonomies based on these data share the same focus on technological innovation in manufacturing. For example, Archibugi *et al.* (1991) derive a taxonomy of industrial sector based on the endogenous or exogenous nature of their technological change's sources (pg 299). Five groups are identified which are consistent with the main typologies spotted by Pavitt (1984), also if the "supplied dominated" group is split in two[79]. This first taxonomy was derived by descriptive statics' of newly available data. A different approach was followed by Cesaratto and Mangano (1993), who used a combination of principal component analysis and cluster analysis to derive an empirical taxonomy of Italian manufacturing innovative firms. They found six different clusters according to differences in technological inputs, technological outputs and the impact of innovation on sales.

This pattern of first producing classifications based on descriptive statistics when new data are available and then deriving taxonomies based on more robust statistical techniques can be observed in the studies based on the first available services' data. So, for example, Sirilli and Evangelista (1998) compare manufacturing and service innovative firms using descriptive statistics to discuss the similarities and differences in terms of structural characteristics and innovation activities[80]. They don't do a proper

[79]The "supplied dominated" is divided in "traditional producers of consumer goods" and "traditional suppliers of intermediate goods". See Archibugi *et al.*, 1991, pp 308-310 for a full description of all the five groups

[80] Type, sources, impact, source of information, obstacles and objects of innovation.

taxonomy, but they profile the innovative activities of service firms through descriptive statistics for each subsector.

In a series of paper, Evangelista and Savona (1998) and Evangelista (2000) proposed one of the first empirical taxonomy of firms in the service sector using Italian CIS data. This doesn't mean that taxonomies based on other dataset were not suggested. For example, Antonelli *et al.*, (2000) classified service firms in the IDE-CNR dataset according to the criteria of tradeability, productivity, networking and infrastructural effects, identifying six different kinds of services.[81] But the already described Evangelista's taxonomy[82] was the first – and to the best of our knowledge still only – based on Italian CIS data.

After the taxonomies produced in the nineties and in the early part of the following decade, the interest in the classification of Italian innovative firms decreases and no new taxonomies based on CIS data were proposed, either in the manufacturing or the service sector.

The present paper is actually an attempt to renew this strand of the literature, on the wave of the new integrated taxonomy advanced in the last years, based on the use of CIS data aggregated at EU level (Castellaci 2008, Peneder 2010).[83] So we try to derive an integrated taxonomy of the Italian innovative firms using data from the CIS-2008 survey

3) Data and methodology

To build our empirical integrated taxonomy of Italian innovative firms we use the CIS-2008 dataset provided by ISTAT in form of microdata file for scientific research (MFR). The dataset contains 19904 observations and 141 variables[84]. The data were collected between February 2009 and December 2009. The survey covers firms with more than 10 employees, with a stratified random sample extraction of those up to 249 employees

[81] For a description of the IDE-CNR dataset and of the different service typologies see Antonelli *et al.*, 200, pp203-211.

[82] See section 2.2

[83] See section 2.3

[84] Data at firm level are provided by ISTAT in anonymised form for privacy reasons. To avoid the possibility of identifying the respondent, some information are deleted (like name and address) and some of the numerical variable are modified if believed at risk to disclose the firms' identity. However, this doesn't affect the representatively of the sample. For a description of the procedures used to anonymize the data and their consequences see Franconi and Ichim (2007).

and a census coverage of those with 250 or more employees[85]. Data were collected mainly through an ISTAT's dedicated website where firms were asked to fill the CIS questionnaire. Data were collected at a firm level, with a coverage of all the major NACE sectors[86]. The structure of the survey follow the "typical" structure of CIS surveys[87]. The main changes from the previous CIS4 survey are: the abolition of the questions on obstacles to innovation; the elimination of the question on the means of IPR protection and the introduction of a section on the environmental impact of innovation. These changes and the impact that they have on the censored character of the CIS survey have been already discuss elsewhere[88].

To use these data to derive our taxonomy we have to choose first the classificatory dimensions to cluster our firms and then the variables used as proxies of the selected dimensions. Most of the empirical taxonomies based on CIS data reviewed in the previous session derive their taxonomies from some combinations of innovative inputs (such as the amount of resources devoted to R&D or kinds of innovation sources), innovative output (such as the number of new products and processes), measures of innovation's impact (such as the percentage of turnover deriving from the introduction of innovation) obstacles to innovation or means of IPR protection. As just said, these last two kind of variables are not included in the Italian CIS 2008 survey. Moreover, as in the previous waves of the survey, data like those on innovative inputs and resources devoted to innovation are collected only for firms identified as "innovative", which means those introducing a new product and/or process[89].

[85] A detailed description of CIS 2008 survey is provided by ISTAT in the methodological files downloadable with the macrodata from ISTAT's website http://www.istat.it/it/archivio/18776
[86] At European level, CIS 2008 covers: mining and quarrying (NACE 05-09); manufacturing (NACE 10-33); electricity, gas steam and air conditioning supply (NACE 35); water supply; sewerage, waste management and remediation activities (NACE 36-39); wholesale trade, except of motor vehicles and motorcycles (NACE 46); transportation and storage (NACE 49-53); publishing activities (NACE 58); telecommunications (NACE 61); computer programming, consultancy and related activities (NACE 62); information services activities (NACE 63); financial and insurance activities (NACE 64-66); architectural and engineering activities; technical testing and analysis (NACE 71).
Additionally, the Italian CIS covers also NACE Rev. 2 sections F and I, and NACE Rev. 2 divisions 45, 47, 59, 68, 72, 77. These information are taken from the methodological description of the dataset provided by ISTAT with the microdata files and available on the ISTAT's website http://www.istat.it/it/archivio/18776
[87] See chapter II section 5 on this point
[88] See chapter II section 5 on this point
[89] See chapter II section 5 on this point

This implies that data on innovative inputs and outputs are not available, for example, for firms introducing an organizational innovation. So taxonomies based on this restricted idea of what an innovative firms is can be very deep but they lack of breadth.

In our taxonomy we decide to embrace an all comprehensive definition of innovative firm following directly from the adoption of the Schumpeterian innovation definition. If we agree with Schumpeter (1934) and we consider an innovation as a new product, a new process, a new market, a new source of supply of raw materials or a new organization, then the logical consequence is to consider an innovative firm the one introducing at least one new product (good or service) or process, a new organizational procedure or a marketing novelty. This enlarged definition of innovative firm covers almost the entire spectrum of the original Schumpeterian innovation concept[90]

But giving the structure of the CIS survey, augmenting the extent of our innovative firm concept means losing the possibility of having information on resources spent on innovation and on the sources of innovation.

This is a price we are willing to pay and comes as a consequence of our choice to adopt a Schumpeterian definition of innovation. The "integrated" character of our taxonomy means that we want to consider in a single theoretical framework not only manufacturing and innovation firms, but also all the possible forms innovation can take. Treating on an equal base technological and non-technological innovations is the direct consequence of the acknowledgement that different forms of innovation are important both in service and manufacturing.

So we will profile our firms according to the types and number of innovation activities performed, estimated using the different kinds of process, organizational and marketing innovations surveyed.

So we will use the series of questions in the CIS-2008 survey that ask to a the firm if has introduced a new product (good of service) innovation, a new process[91] innovation, a new organization[92] innovation or a new marketing[93] innovation.

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[90] See chapter II section 2.1 on this point

[91] Three different kinds of process innovations are distinguished: "new or significantly improved method of production"; "new or significantly improved logistic, delivery or distribution system"; and "new or significantly improved supporting activities".

[92] Three different kinds of organizational innovations are distinguished: "new business practices for organising work or procedures"; "new methods of workplace organisation"; and "new methods of organising external relations".

We will rely on these questions to build 3 separate indicators, each for every type of innovation activity, calculated as the mean score of the different items in the same category. So we have an indicator for technological innovation activities (5 items, Cronbach's Alpha = 0.809); another for organizational innovation activities (3 items, Cronbach's Alpha = 0.735); and the third one for marketing innovation activities (4 items, Cronbach's Alpha = 0.720).

We use then these three indicators in combination with other two groups of variables regarding the structural characteristic of the firms. The first one regards the value of firm's turnover in the first and in the last period of observation (2006 and 2006), while the second group is formed by a series of dummy variables informing us about the markets[94] in which the firm operate. We use all those variables to perform a factor analysis (Hair, *et al.*, 2010) to extract the factors than we will use in the following cluster analysis. We perform a factor analysis using the principal components as method of extraction, using the standard criterion of considering only eigenvalues>1 to decide if a factors has to be considered or not. The Bartlett's Test is significant at 0.01% level an all the variables have values of the measure of sample adequacy (MSA) > 0.6, which is inside the acceptable range (MSA>0.5)[95]. The factors extracted are three, a solution that extract 60,54% of total variance, meeting the common minimum requirement criteria of 60%.

Table 4.1 reports the rotated component matrix (varimax rotation), with the factor loading for each factor. We can clearly identify a first "sales market factor"; a second "turnover factor"; and a final "innovation activities factor".

We will use this factor now to perform a cluster analysis using a two steps cluster procedure. But before that, let's have a look to some descriptive statistics about the CIS 2008 database.

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[93] Four different kinds of marketing innovations are distinguished: "significant changes to the aesthetic design or packaging"; "new media or techniques for product promotion"; "new methods for product placement or sales channels"; and "new methods of pricing goods or services".

[94] The four dummy variables are: "local/regional market"; "national market"; "Other EU/EFTA/CC market"; and "All other countries"

[95] Turnover 2006 and turnover 2008 have a value of MSA of 0.515 and 0.514 respectively, which is still however greater than the threshold of 0.5

Table 4.1 Rotated Component Matrix[a]			
	Component		
	1	2	3
Technological innovation activities	.202	.030	.666
Organization innovation activities	-.111	.060	.750
Marketing innovation activities	.027	.070	.655
Total turnover in 2006	.041	.984	.086
Total turnover in 2008	.032	.984	.085
Local/regional market	-.265	.003	.078
National market	.645	.038	.127
Other EU/EFTA/CC market	.877	.027	.091
All other countries	.834	.035	.105

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 4 iterations.

4) Some descriptive statistics

Out of 19904 firms included in the CIS-2008 sample, 9943 (49.95%) have introduce in the previous three years at least a product, process, organizational or marketing innovation. We call them "innovative firms in a Schumpeterian way" to make a distinction from innovative firms in a "narrow technological way". So roughly half of the firms surveyed have performed at least an innovation activity that has led to the introduction of a commercially successful innovation. If we include also the firms that have reported only abandoned and/or on-going innovation activities 234, the number of innovative firms grows to 10177 (51.13%)[96].

Table 4.2 shows the sectoral composition of the sample and the percentage of innovative firms for each sector of economic activity at a 1 digit level of aggregation.

[96] These 234 firms that have reported only abandoned and/or ongoing innovation activities are not included in the analysis. Given their limited number, this exclusion doesn't affect the results and conclusions presented.

Tab 4.2 - Sample composition by sectors of economic activity				
Sectors of Economic activity (Nace rev2 - 1 digit)	Number of Firms		Number of innovative firms in a Schumpeterian way	
	Count	As a percentage of the total number of firms	Count	As a percentage of the total number of firms
Mining and quarrying	195	0.98%	69	35.38%
Manufacturing	6483	32.57%	3983	61.44%
Electricity, gas steam and air conditioning supply	184	0.92%	103	55.98%
Water supply; sewerage, waste management and remediation activities	513	2.58%	266	51.85%
Construction	4368	21.95%	1550	35.49%
Wholesale trade, except of motor vehicles and motorcycles	3437	17.27%	1594	46.38%
Transportation and storage	1255	6.31%	543	43.27%
Accommodation and food service activities	1473	7.40%	568	38.56%
Information and Communication	630	3.17%	400	63.49%
Financial and insurance activities	803	4.03%	569	70.86%
Real estate activities	152	0.76%	54	35.53%
Professional, scientific and technical activities	320	1.61%	199	62.19%
Administrative and support service activities	91	0.46%	45	49.45%
Total	19904		9943	49.95%

Firms in the manufacturing sector represent a third of the sample. 61.44% of them have performed at least an innovation activity in the previous three years. The figure for the service sector overall is slightly lower. Out of 8161 service firms[97], which represent

[97] For "service sector firms", in the present chapter context we refer to firms in the following Nace rev 2 classes: "Wholesale trade, except of motor vehicles and motorcycles (G)"; "Transportation and storage (H)"; "Accommodation and food service activities (I)"; "Information and Communication (J)"; "Financial

41.0 % of the total sample, 3972 (48.67%) are innovative firms. Among the different activities following under the umbrella category of service, sectors like "Information and Communication (J)"; "Financial and insurance activities (K)"; and "Professional, scientific and technical activities (M)" show rates of innovative firms' presence comparable to the manufacturing sector. As expected, firms in the more traditional segment of the service sector, such as "Accommodation and food service activities (I)"; or "Real estate activities (L)" present the low rates firms performing innovation activities. If we break down at a two digit level the manufacturing and service sector firms, we can find very significant differences in the distribution of innovative firms among them (see table 4.2.A and 4.2.B in the appendix).

In the manufacturing sector, "pharmaceutical products and pharmaceutical preparations (21)"; "manufacture of chemicals and chemical products (20)"; "computer, electronic and optical products (26)"; and "motor vehicles, trailers and semi-trailers (29)" are subsectors where every 10 firms, at least 8 have performed one or more innovation activities in the previous three years. The two subsectors of "manufacture of leather and related products (15)" and "manufacture of wearing apparel (14)" are instead those showing the lowest value of the ratio between innovative firms and total number of firms (slightly less than 5 over 10).

In the service sector, we register a greater disparity between rates of innovative firms among different subsectors, as easily predictable given the composite nature of the activities labelled as "service". So, from one hand we have subsector such as "telecommunications (61)"; "insurance, reinsurance and pension funding, except compulsory social security (65)"; "scientific research and development (72)"; "financial service activities, except insurance and pension funding (64)"; and "computer programming, consultancy and related activities (62)", that show rations of innovative firms comparable to those of the more innovative manufacturing subsectors.

From the other hand, in subsector like "water transport (50)"and "real estate activities (68)", less than 4 firms every 10 declare to have performed an innovation activity in the 2006-2008 period. This figure drop to 2.5 every 10 for the "food and beverage service

and insurance activities (K)"; "Real estate activities (L)"; "Professional, scientific and technical activities (M)";and "Administrative and support service activities (N)".

activities (56)" subsector, that register the worse performance in terms of share innovative firms of the manufacturing and service sector taken together.

The fact that innovation is less equally distributed among subsectors in service rather than manufacturing is confirmed also by the value of concentration indexes like the Herfindahl–Hirschman Index (HHI) and the C4-index.

First we compute the ratio of innovative firms for each subsector computed as the number of innovative firms over the total number of firms of each sector[98]. Then being 100 the sum of these ratios, we consider the relative shares of each sector as a sort of "market shares". Finally we use those shares to compute the HHI and the C4-index for the manufacturing and the service sector. As expected, both indexes have an higher value in the service sector than in the manufacturing. The HHI[99] for the service sector is 447.67, greater than the 496.48 value computed for the manufacturing. The C4-index has a value of 22.5% for the manufacturing sector, meaning that the first 4 sub-sectors in terms of innovative firms' ratio represent jointly the 22.5% of the total amount of the character. The value of the same index for the service sector is 27.6%, indicating a greater concentration of the ratio of innovative firms in the first 4 service subsectors compared to the first 4 manufacturing ones.

The figures shown in this section about innovative firms are based on our methodological choice [100] of considering an "innovative firm" a firm that have introduced either a new product; or process; or organizational; or marketing innovation. Broadening the definition, instead of adopting the narrow technological one, has clearly consequences on every analysis we decide to carry on our data. Table 4.3 gives an idea of the magnitude of the this effect, comparing the distribution of innovative firms among sectors according to the different definition chosen.

[98] We do this to take into account the fact that the number of firms in our sample is very different in each subsector. So if we use the absolute number of innovative firms we are picking up more a kind of size effect (the bigger the sector, the more the innovative firms) than the actual concentration in a specific sector of innovative firms.

[99] The HHI can vary between 0 and 10000, with values greater than 1000 considered as index of presence of concentration.

[100] See section 3

Tab 4.3 - "Innovative Schumpeterian" firms vs. "Innovative technological" firms						
Sectors of Economic activity (Nace rev2 1 digit)	Number of innovative firms in a Schumpeterian way		Number of innovative firms in a narrow technological sense		Differences in the number of innovative firms according to the definition used	
	Count	As a percentage of the total number of firms	Count	As a percentage of the total number of firms	Count	Percentage difference in the innovative firms
Mining and quarrying	69	35.38%	17	8.72%	-52	-75.36%
Manufacturing	3983	61.44%	2468	38.07%	-1515	-38.04%
Electricity, gas steam and air conditioning supply	103	55.98%	40	21.74%	-63	-61.17%
Water supply; sewerage, waste management and remediation activities	266	51.85%	107	20.86%	-159	-59.77%
Construction	1550	35.49%	576	13.19%	-974	-62.84%
Wholesale trade, except of motor vehicles and motorcycles	1594	46.38%	601	17.49%	-993	-62.30%
Transportation and storage	543	43.27%	207	16.49%	-336	-61.88%
Accommodation and food service activities	568	38.56%	227	15.41%	-341	-60.04%
Information and Communication	400	63.49%	286	45.40%	-114	-28.50%
Financial and insurance activities	569	70.86%	337	41.97%	-232	-40.77%
Real estate activities	54	35.53%	14	9.21%	-40	-74.07%
Professional, scientific and technical activities	199	62.19%	114	35.63%	-85	-42.71%
Administrative and support service activities	45	49.45%	24	26.37%	-21	-46.67%
Total	9943	49.95%	5018	25.21%	-4925	-49.53%

Columns 1 and 2 reported the figures (in absolute and percentage terms) of “innovative firms in a Schumpeterian way” already present in table 4.2. These figures are compared with those in columns 3 and 4, that represent the number (again in absolute and percentage terms) of innovative firms in a “narrow technological way”. This means that if – as the majority of the empirical studies on firm innovation does – we consider an “innovative firm” only a firm that have introduced a new product and/or a process innovation, out of 19904 firms included in the CIS-2008 sample, only 5018 are “innovative” (25.21%)[101]. The interesting part of table 4.3 are columns 5 and 6, that reported the difference (absolute number and percentage terms) in the number of “innovative firms” depending on the definition we choose. Of course, to a narrow definition corresponds lower figures of innovative firms in each of the sector considered. In the service sector considered overall, the 3972 innovative firms are reduced to 1810, with a decrease of -54.43%. In the manufacturing sector there’s also a drop in innovative firms of -1515, equals to a reduction of the 38.04%.

It’s not surprising that, if we consider “innovative firms” only those introducing a technological innovation, than the number of innovative service firms drops significantly. That’s because we know that service firms are more prone to “soft” aspect of innovation (Tether, 2003 and 2005). And the reduction of the innovative firms’ number is in a way also incidentally an indirect of organizational and marketing innovations’ importance for the sector.

More interesting is that also the reduction in the count of innovative firms in the manufacturing sector is fairly consistent. This is an indirect confirmation of the importance of soft aspect of innovation also in the manufacturing sector.

If we look closely to service branches, not surprisingly we find that in some of them the drop is very consistent (like in the “real estate activities (L)” or “wholesale trade, except of motor vehicles and motorcycles(G)”). In others, the reduction registered in the number of innovative firms due to definition’s change is quite small, even smaller than the one of manufacturing, as in the case of “Information and Communication (J)”.

[101] We should include in this count also the 234 firms that have reported only abandoned and/or ongoing innovation activities, which takes the number of “innovative” firms up to 5252 (26.38%).

All in all, the comparison between the consequences of different definition of what an "innovative firm" is confirms the importance of organizational and marketing innovations also in the manufacturing sectors. If we look at the data at a more disaggregate level (tables 4.3.A and 4.3.B in the appendix), our conclusion does not change: "soft" aspect of innovation are important for all economic sectors, and disparities seems to emerge more "within" than "between" macro sectors.

Table 4.4 move focus the attention on the types of innovations introduced by the 9943 innovative firms in our sample.

Overall, the most reported kind of innovation introduced is "New methods of workplace organisation", with 49.94% of our innovative firms having introduced this type of organizational innovation in the previous three years period. The following two kind of innovations in the most diffused list are two more traditional types of technological innovation: "Introduced onto the market a new or significantly improved supporting activities" (process innovation, 44.24%) and "Introduced onto the market a new or significantly improved good" (product innovation, 39.39%).

Interesting to notice that, among the 12 possible kind of innovations surveyed, 3 out of the 4 at the bottom of the diffusion list are marketing innovations, with "new methods for product placement and sales channels" having been introduced by only 16.6% of the innovative firms in our sample.

If we narrow the focus to the manufacturing sector, not surprisingly the most common kind of innovation is "introduced onto the market a new or significantly improved good" (59.0%), followed by two forms of process innovations. The central role of technological innovation activities was somehow expected. The fact that also non-technological innovation plays a non-marginal role in the manufacturing sector is instead an interesting fact. "New methods of workplace organisation" have being introduced by 44.97% of the innovative manufacturing firms. As for the overall sample of innovative firms, also in the manufacturing sector the less common kind on innovation introduced is "new methods for product placement or sales channels", with just 13.48% of the innovative manufacturing firms reporting it.

Taking into account only the service sector, the innovation activities most performed by the innovative firms is "new methods of workplace organisation" (52.39%) followed by "new media or techniques for product production" (46.85%).

Tab 4.4 - Types of innovations introduced by sector of economic activity											
Total				Manufacturing				Services			
Innovation introduced	type	Count	As a % of Innovative firms	Innovation introduced	type	Count	As a % of Innovative firms	Innovation introduced	type	Count	As a % of Innovative firms
New methods of workplace organisation	Organizational	4966	49.94%	Introduced onto the market a new or significantly improved good	Product (good or service)	2350	59.00%	New methods of workplace organisation	Organizational	2081	52.39%
Introduced onto the market a new or significantly improved supporting activities	Process	4399	44.24%	Introduced onto the market a new or significantly improved method of production	Process	2183	54.81%	New media or techniques for product promotion	Marketing	1861	46.85%
Introduced onto the market a new or significantly improved good	Product (good or service)	3917	39.39%	Introduced onto the market a new or significantly improved supporting activities	Process	1957	49.13%	Introduced onto the market a new or significantly improved supporting activities	Process	1614	40.63%
Introduced onto the market a new or significantly improved method of production	Process	3721	37.42%	New methods of workplace organisation	Organizational	1791	44.97%	Introduced onto the market a new or significantly improved service	Product (good or service)	1546	38.92%
New media or techniques for product promotion	Marketing	3549	35.69%	New business practices for organising work or procedures	Organizational	1544	38.76%	New business practices for organising work or procedures	Organizational	1389	34.97%
New business practices for organising work or procedures	Organizational	3499	35.19%	Significant changes to the aesthetic design or packaging	Marketing	1262	31.68%	New methods of pricing goods or services	Marketing	1263	31.80%
Introduced onto the market a new or significantly improved service	Product (good or service)	3173	31.91%	New media or techniques for product promotion	Marketing	1158	29.07%	New methods of organising external relations	Organizational	1206	30.36%
New methods of organising external relations	Organizational	2762	27.78%	Introduced onto the market a new or significantly improved service	Product (good or service)	1029	25.83%	Introduced onto the market a new or significantly improved good	Product (good or service)	1124	28.30%
Significant changes to the aesthetic design or packaging	Marketing	2315	23.28%	Introduced onto the market a new or significantly improved logistic, delivery or distribution system	Process	986	24.76%	Introduced onto the market a new or significantly improved method of production	Process	961	24.19%
New methods of pricing goods or services	Marketing	2315	23.28%	New methods of organising external relations	Organizational	896	22.50%	New methods for product placement or sales channels	Marketing	939	23.64%
Introduced onto the market a new or significantly improved logistic, delivery or distribution system	Process	2048	20.60%	New methods of pricing goods or services	Marketing	809	20.31%	Significant changes to the aesthetic design or packaging	Marketing	926	23.31%
New methods for product placement or sales channels	Marketing	1651	16.60%	New methods for product placement or sales channels	Marketing	537	13.48%	Introduced onto the market a new or significantly improved logistic, delivery or distribution system	Process	775	19.51%

While this is not surprising, it's interesting to notice that 4 out of 10 innovative service firms have "introduced onto the market a new or significantly improved supporting activities" and almost the same percentage (38.92%) have "introduced onto the market a new or significantly improved service". These two last innovation activities are of a technological nature, showing how in the service sector not only non-technological innovation matters.

Very different patterns regarding the kind of innovation introduced are observed also among the manufacturing and service subsectors at a 2 digit level (see tables 4.4.A and 4.4.B in the appendix). This variety support the hypothesis that the innovative patterns go beyond the traditional boundaries of economic activities classification.

The final table 4.5 gives us an idea of the intensity of each different type of innovation (product; process; organizational; and marketing) performed by sector of economic activity

Tab 4.5 - Average number of innovative activities performed by each innovative firm

Sectors of Economic activity (Nace rev2 - 1 digit)	Product (good or service) innovations (max 2)	Process innovations (max 3)	Organizational innovations (max3)	Marketing innovations (max 4)	Overall (max 12)
Mining and quarrying	0.35	1.13	0.75	0.51	2.74
Manufacturing	0.85	1.29	1.06	0.95	4.14
Electricity, gas steam and air conditioning supply	0.50	0.96	1.36	1.01	3.83
Water supply; sewerage, waste management and remediation activities	0.50	0.98	1.27	0.47	3.21
Construction	0.54	0.81	1.16	0.52	3.03
Wholesale trade, except of motor vehicles and motorcycles	0.54	0.72	1.06	1.37	3.68
Transportation and storage	0.51	0.92	1.23	0.76	3.42
Accommodation and food service activities	0.57	0.63	0.77	1.63	3.59
Information and Communication	1.12	1.04	1.42	1.02	4.60
Financial and insurance activities	0.98	1.17	1.70	1.50	5.34
Real estate activities	0.37	0.63	1.09	0.94	3.04
Professional, scientific and technical activities	0.78	0.97	1.23	0.50	3.48
Administrative and support service activities	0.78	0.84	1.02	1.38	4.02
Total service activities	0.67	0.84	1.18	1.26	3.95
Total overall	0.71	1.02	1.13	0.99	3.85

The average number of innovation activities performed by every innovative firms is 3.85 (out of a theoretical maximum of 12) and is disaggregated by the kind of innovation performed and the sector of economic activity. As expected, the manufacturing sector shows a higher innovation intensity than the service one (4.14 against 3.95 average innovation activities performed per innovative firm), but the distance is in the end not so big. Manufacturing innovative firms perform on average more technological innovation activities than the service ones, which instead have a better performance in terms of organizational and marketing innovation activities. The interesting results are one again the great variety of innovative patterns experienced by different service branches, with some of them – like "Information and Communication (J)"; or "Financial and insurance activities (K) - scoring similarly to the manufacturing sector. In addition, also when we consider the service sector all together, is performance is terms of innovative activities carried on is not so distant form the manufacturing's one. Those results are confirmed on a two digit level breakdown (see tables 4.5.A and 4.5.B in the appendix), where the variability is even more evident.

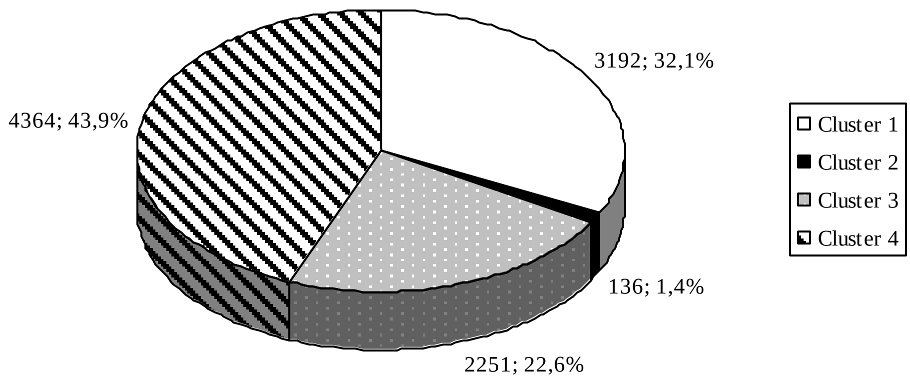
5) Clusters of innovative firms

Given the large number of observation we are dealing with, we use a two steps cluster procedure, as suggested by Everitt, et al.(2011, pg .97). with a two steps cluster procedure, the clustering algorithm works first to assign to each observation a pre-cluster membership to a large number of little sub-clusters according to a log-likelihood distance criterion. Than in the second step, on the basis of this membership, the sub-clusters are aggregated into larger clusters. This procedures mix the advantages of hierarchical and non-hierarchical methods, allowing to deal with large dataset and at the same time letting the data decide how many clusters to form.

SPSS performs the procedure automatically and the final result, using our three factors previously extracted[102], is a 4 cluster solution. The number of firm in each cluster and the size in terms of class number of employees in 2008 are reported in figure 4.6

[102] See section 3 in this chapter

Fig 4.6 Number of firms by cluster of membership



Cluster 4 is the biggest, with 4364 innovative firms (43.9% of the total), followed by cluster 1 (3192, 32.1%) and cluster 3 (2251, 22.6%). The last group, cluster 2, is quite small, only 136 firms, the 1,4% of the total. But, the interesting thing is that almost all of them (97%) are big firms (250 employees or more). So we decided to keep also this small cluster and adopt the 4 cluster solution.

Tab 4.7 - Firm class of employees' number by cluster of membership

Class of employees' number 2008	Cluster membership				Total
	1	2	3	4	
10_49	53%	0%	54%	78%	64%
50-249	31%	3%	24%	15%	22%
250+	16%	97%	22%	6%	14%

Tables 4.8, 4.9 and 4.10 give us useful information to profile the four cluster obtained in the two-steps procedure.

The first of this tables' series , table 4.8, gives us the main sector of economic activity (I digit) of the firm in each cluster (in percentage of the firms' cluster total).

So for example Cluster 1 is characterized by a strong presence of manufacturing firms, accounting for 66% of all the firms in the cluster. In cluster 2, service sector overall plays a dominant role, particularly the "financial and insurance Activities (K)", that represent 1 firm every 5 in this sector. In cluster 3, manufacturing and services are almost equally present, while cluster 4 sees a strong presence of the construction sector, accounting for 27.89%. Cluster 4 is overall service dominated, with a 44,43 presence of service firms.

Tab 4.8 - Percentage number of firms by main sector of economic activity and by cluster of membership

Sectors of Economic activity (Nace rev2 - 1 digit)	Cluster membership				Overall
	1	2	3	4	
Mining and quarrying	0.41%	1.47%	0.31%	1.08%	0.69%
Manufacturing	66.01%	33.09%	41.54%	20.53%	40.06%
Electricity, gas steam and air conditioning supply	0.22%	8.82%	1.02%	1.40%	1.04%
Water supply; sewerage, waste management and remediation activities	0.53%	0.00%	2.00%	4.67%	2.68%
Construction	2.98%	1.47%	10.48%	27.89%	15.59%
Wholesale trade, except of motor vehicles and motorcycles	10.53%	15.44%	16.88%	19.64%	16.03%
Transportation and storage	5.33%	8.09%	4.44%	6.00%	5.46%
Accommodation and food service activities	6.89%	0.00%	5.11%	5.34%	5.71%
Information and Communication	2.44%	7.35%	5.69%	4.22%	4.02%
Financial and insurance activities	1.50%	22.79%	10.04%	6.05%	5.72%
Real estate activities	0.25%	0.00%	0.40%	0.85%	0.54%
Professional, scientific and technical activities	2.66%	1.47%	1.42%	1.83%	2.00%
Administrative and support service activities	0.25%	0.00%	0.67%	0.50%	0.45%
Total service activities	29.86%	55.15%	44.65%	44.43%	39.95%
Total overall	100.00%	100.00%	100.00%	100.00%	100.00%

Taken all together, cluster 1 seems “manufacturing dominated”; cluster 4 appears “service dominated”; cluster 3 looks more or less split between the two; and cluster 2, although it records a majoritarian presence of services, is quite small in absolute terms. This means that in the results of our cluster analysis, we can find a mild division of sectors of economic active in our 4 clusters, with two of them clearly dominated by a single aggregate sector (manufacturing or service) and a third in which the two are mixed together. So this is a first characteristic of our clusters the predominance (or not) of firm belonging to particular sectors.

Table 4.9 adds another piece to our puzzle, showing us the percentage of firms in each cluster engaged in a particular number of innovation activities

So in cluster 1, 65% of the firms are engaged in no more than three innovation activities. Better, in the previous three years, have introduce no more than 3 different typologies of innovation over a total of 12 possible innovation activates surveyed. In cluster 4, this percentage (of firms introducing no more than three different kinds of innovations) raises to 78.05. This means that firms in clusters 1 and 4 are engaged in very specific kinds of innovation activates[103], lacking in variety of innovations introduced.

This kind of "innovation narrowness" has not to be confused with no or scares innovativeness. A firm can be very innovative, introducing a considerable number of innovations, but if they are all of the same types, in our taxonomy will be labelled as affected by "innovation narrowness". Opposite to these two "narrow" clusters just described, clusters 3 and 2 are characterized by "innovation wideness". In cluster 3, for example, 99.51% of the firms perform at least 5 innovation activities, percentage that decrease to 73.53% in the case of cluster two, but still means that 3 out of 4 firms in that clusters perform at least 5 innovation activities. This is a second evident features of our clusters: two of them are characterized by "innovation narrowness"- which can be seen as the "dark side" of specialization - while the other two show clear signs of "innovation wideness".

Tab 4.9 - Percentage of firms engaged in a specific number of innovation activities by cluster of membership

Number of innovation activities performed	Cluster membership				Total
	1	2	3	4	
1	23.31%	5.15%	0.00%	32.56%	21.84%
2	21.74%	3.68%	0.00%	26.35%	18.60%
3	19.33%	9.56%	0.00%	19.13%	14.73%
4	14.60%	8.09%	0.49%	13.79%	10.96%
5	12.00%	9.56%	8.35%	7.61%	9.21%
6	6.42%	14.71%	20.44%	0.55%	7.13%
7	2.41%	8.09%	21.86%	0.00%	5.83%
8	0.19%	8.09%	18.35%	0.00%	4.32%
9	0.00%	4.41%	11.64%	0.00%	2.70%
10	0.00%	8.09%	10.08%	0.00%	2.39%
11	0.00%	9.56%	6.00%	0.00%	1.49%
12	0.00%	11.03%	2.80%	0.00%	0.78%
Total	100.00%	100.00%	100.00%	100.00%	100.00%

[103] There is the possibility that these firms are engaged also in other kinds of innovation not covered in the survey. So they are not "innovative narrow", but it's just that our questionnaire does not cover other kind of innovations performed by these firm. But, given the width of the innovation activities covered in the CIS 2008 survey, this possibility of having not recorded "other" different kinds of innovation is more theoretical than real.

Finally, table 4.10 adds another information useful for our attempt to characterized the 4 cluster emerged in the analysis. We have just seen that our clusters can be divided in "innovative narrow" and "innovative wide". Now it's worth concentrate our attention on which specific part of the innovation spectrum the narrow clusters are focused on. Different kind of "narrowness" can emerge. Given the type of data used in the analysis, three basic kinds of "narrowness" can emerge: technological; organizational; and marketing (or some combination of them). Table 4.10 provides precisely this kind of information; the percentage of firms having introduced a particular kind of innovation over the total of firms in the cluster .

Tab 4.10 Percentage of firms introducing a specific types of innovation by cluster of membership

Types of innovation		Cluster membership			
		1	2	3	4
Product (good or service) innovations	Introduced onto the market a new or significantly improved good	47.2%	63.2%	68.4%	17.9%
	Introduced onto the market a new or significantly improved service	21.4%	51.5%	64.7%	22.1%
Process innovations	Introduced onto the market a new or significantly improved method of production	38.2%	55.1%	66.9%	21.1%
	Introduced onto the market a new or significantly improved logistic, delivery or distribution system	14.3%	41.2%	52.1%	8.3%
	Introduced onto the market a new or significantly improved supporting activities	38.6%	66.9%	79.7%	29.4%
Organizational innovations	New business practices for organising work or procedures	23.8%	79.4%	75.8%	78.8%
	New methods of workplace organisation	31.8%	80.9%	88.1%	42.6%
	New methods of organising external relations	12.9%	58.1%	64.6%	18.7%
Marketing innovations	Significant changes to the aesthetic design or packaging	22.0%	41.9%	51.8%	8.9%
	New media or techniques for product promotion	24.3%	55.1%	65.7%	28.0%
	New methods for product placement or sales channels	8.9%	45.6%	43.4%	7.5%
	New methods of pricing goods or services	16.8%	50.0%	49.9%	13.5%

Not surprisingly, clusters 2 and 3 show high value of firms performing every kind of innovation activities. In cluster 3, there is always at least half of the firms that have reported the introduction on the particular innovation. This is consequential to the

“innovation wideness” characteristic already detect looking at the number of innovation activities performed by the firms in the cluster. More interesting is to have a look of what kind of innovations are introduced by the firms in the clusters 1 and 4, those characterized by “innovation narrowness”. In case of cluster 1, almost one firms every two firms has “introduced onto the market a new or significant improved good” . Significant or improved method of production or supporting activities (two kind of process innovation) have been introduce onto the market by 38.2 and 38.56 % of the firms in the cluster. So, even if 31.8% of cluster’s firms have introduced also a new method of workplace organization (which is an organizational innovation), the kind of “innovative narrowness” affecting the cluster is clearly one of the technological type.
This is also consistent with the observation about the economic sectoral composition of cluster 1, dominated by manufacturing firms, typically firms quite keen on the technological side of innovation activities.
The “kind of narrowness” diagnostic is even more easy for cluster 4. In this group, 78.8% of the firms have reported to have implemented a “new business practices for organising work or procedures” in the previous three years. 4 every 10 firms in this cluster have also introduced “new methods of workplace organisation”, another kind of organizational innovation. So we can quite safely conclude that the type of narrowness characterizing this cluster is of organisational nature. As in the case of cluster 1, also for cluster four there is a consistency between the type of narrowness detected and the characteristics of the economic sector in which this cluster’s firms mainly operate: the service sector. As we have seen previously[104], non-technological or “soft” kinds of innovation are the most common in service sector.
With all the elements considered in this section so far, we can try to trace the profile of our 4 clusters.
Cluster one: technological innovators. In this clusters we find mainly (but not only) manufacturing firms of small and medium size, characterized by a narrow innovative focus on few kinds of technological innovation.
Cluster 4: organizational innovators. In this clusters we find mainly service firms, with a huge chunk constitute by construction sector’s firms. Typically of small size, their

[104] See Section 4

innovation activities are concentrated around non technological kinds of innovation, mainly of the organizational type.

Cluster 3: wider innovators. This clusters is composed by manufacturing and service firms roughly in the same percentage, with three quarters of firms being small or medium size. The main characteristic of these firms is performing different kinds of innovation activities at the same time. With “different kinds” we don’t mean, for example, two different types of process innovations, but we suggest the mix of technological and non-technological kinds of innovation activities.

Cluster 2: white whales. This small cluster is formed by big firms (more than 250 employees) belonging to different sectors, from the financial to the manufacturing one. Those firms show a strong commitment to variety in innovation activities, and perform most of the surveyed typologies of innovation.

6) Conclusions

In this paper we tried to derive and empirical taxonomy using data on the Italian innovative firms. We start from a brief review of the existing taxonomies of innovative firms, beginning with “the mother of all taxonomies” of innovative firms: Pavitt’s taxonomy. Then we move of focus to the taxonomies regarding the service sector and those regarding Italian firms, giving some space also to the new vogue of integrated taxonomies, i.e. those taxonomies dealing in a unique framework with service and manufacturing firms. We found a mismatch in the literature between the width of Schumpeterian formulation of the innovation concept and the restricted use of the technological dimension of innovation to identify “innovative firms” in empirical analysis. This is in part due to a lack of suitable data for taking into account all the possible forms of innovation with the same level of deepness in the analysis.

The last revision of the CIS survey reserves a greater space to non-technological forms of innovation than in the past. This has allowed us to use those new information to derive an integrated taxonomy on the base of a Schumpeterian definition of what an “innovative firm” is. To be able to use an all-embracing definition of “innovative firm”, we have to pay a price in terms of lack of data traditionally used to derive taxonomies of innovative firms, such as data on innovative inputs.

Nevertheless, using our enlarged Schumpeterian definition, we identify more than 9000 innovative firms in the Italian CIS-2008 database.

We use factor analysis to reduce the variability in the data at firm level and then the resulting factor scores to perform a two-steps cluster analysis, given the large number of observation used.

The results is a four clusters solution, where firms are distinguished according to the number of different innovation activities and the kind of these activities that they performed. The four identified pattern of innovation are just partially overlapping traditional distinctions between sectors of economic activities, i.e. manufacturing vs. services. Even if there seem to be kinds of innovation still more suitable for manufacturing firms and others more likely to be performed by service firms, an interesting cluster emerged, where firms of both sectors are grouped together due to their great propensity to engage in several kinds of innovation activities at the same times. This constitute an evidence in support of those arguing for integrate taxonomy and for a revision of the traditional boundaries among economic activities.

This taxonomy has the merit of fully embrace a Schumpeterian definition of innovation, but suffers for the still predominant orientation in data collection toward technological aspects of innovation.

The fact that the Italian CIS-2008 collects data on innovative inputs only for firms that have performed (or are performing now or have tried and failed) a product and/or a process innovation is a severe limitation to the kind of study that we have tried to do in this paper

Nevertheless, this paper can be an useful contribution for those trying to go beyond narrow definition of innovation and can be a valid starting point for similar future analysis, once data also on firms “just” performing organizational and /or marketing innovation will have the same level of deepness and detail of those now collected for technologically innovative firms.

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V. Conclusion: a research agenda for the future

The three essays collected in this thesis try to shed some light on relevant problems connected to innovation in the service sector.
In particular, the first essay, while reviewing the literature on service innovation, points out the initial poor conceptualisation of the concept of innovation itself. Instead of the all-embracing Schumpeterian definition of innovation, the first wave of studies on service innovation adopted the narrow technological version of it, passed through the manufacturing sector. This has created a distortion - the manufacturing bias - that affected and stull affect innovation studies in services. This bias is reflected also in the instrument w use to measure innovation in services. In particular, we have faced the case of CIS survey, the most diffused survey on innovation at European level.
In the second essay, we have make an effort to revise the literature on productivity in services. This field has been long dominated by the idea that services are unproductive for reasons connected to their own nature – that's the famous Baumol's cost-disease argument. Another explanation (not necessarily excluding the first one) of service poor performances in productivity indicators was found in the reliability of data for productivity analysis. We have seen how some scholars, in the attempt to provide betted data to measure productivity in service, have argued against the Baumol's theory.
We have also given account of a parallel debate to the one about natural backwardness and/or poor data quality to explain service unproductive figures. This parallel point of view questions the necessity of using the productivity concept itself in the service sectors analysis, suggesting the use of more adapted multiple dimension indicators. We have argued that both theoretical debates will benefit form a better conceptualization of "outputs" and "inputs" used in the services' production process. In particular, we suggest to walk the road of the characteristic approach to better define the output. While, on the inputs side, the advice is to deepen our understanding of which inputs it's worth saving and of the consequences of different types of input saving changes.
The third essay is an empirical exercise that derives an integrated taxonomy for the Italian innovative firms. We have enlarged the "standard" (in the empirical literature using CIS data) definition of "innovative firm", including also firms introducing non-

technological kinds of innovation. This enlargement of the innovative firms population is in line with the original Schumpeterian definition of what innovation is and has also allow us to explore different innovative patterns across sectors.

Four clusters emerged from the analysis, two of them quite traditional: a manufacturing cluster focused on technological innovation and a service cluster performing mainly non-technological innovation activities. The other two are more interesting, the first one, that we called "wider innovators" is composed by firms – both manufacturing and service firms – engaged in several different types of innovation activities at the same time. The last group – a very small cluster of very big firms that we called "white whale" – is composed only by firms with more than 250 employees, belonging part to the manufacturing and part to the service sector, performing all sort of innovation activities.

Each one of these three works has possible follow ups, partly outlined in the conclusion of the individual essays. A common conclusion of all the three papers is that there's still a lot of work to do in the field of service innovation to reach the level of understanding of the innovation process that we have in the manufacturing sector.

To reach a comparable level of awareness, a rethinking of the measurement tools that we employ and maybe above all of the data that we use to study innovation in the service sector is a matter that needs close attention.

So for example, a further reconsideration of how CIS data are collected and CIS surveys are structured could be a good starting point for collection more service-friendly data, which are the essential base of every future research.

Appendix – additional tables

Tab 4.2.A - Sample composition of the Manufacturing sector - breakdown at a 2 digits level of economic activity

Manufacturing Sector activities	Number of Firms		Number of innovative firms in a Schumpeterian way	
	Count	As a percentage of the total number of firms of the manufacturing sector	Count	As a percentage of the total number of firms
Manufacture of basic pharmaceutical products and pharmaceutical preparations	76	1.17%	68	89.47%
Manufacture of chemicals and chemical products	149	2.30%	124	83.22%
Manufacture of computer, electronic and optical products	162	2.50%	132	81.48%
Manufacture of motor vehicles, trailers and semi-trailers	118	1.82%	96	81.36%
Manufacture of electrical equipment	195	3.01%	149	76.41%
Manufacture of machinery and equipment n.e.c.	458	7.06%	339	74.02%
Manufacture of beverages & Manufacture of tobacco products	108	1.67%	76	70.37%
Manufacture of other transport equipment	65	1.00%	43	66.15%
Manufacture of basic metals	252	3.89%	166	65.87%
Other manufacturing	277	4.27%	177	63.90%
Manufacture of rubber and plastic products	445	6.86%	284	63.82%
Manufacture of coke and refined petroleum products	56	0.86%	35	62.50%
Manufacture of paper and paper products	190	2.93%	115	60.53%
Manufacture of furniture	283	4.37%	171	60.42%
Manufacture of food products	467	7.20%	275	58.89%
Manufacture of other non-metallic mineral products	379	5.85%	218	57.52%
Manufacture of fabricated metal products, except machinery and equipment	736	11.35%	419	56.93%
Repair and installation of machinery and equipment	407	6.28%	230	56.51%
Manufacture of textiles	305	4.70%	169	55.41%
Printing and reproduction of recorded media	415	6.40%	223	53.73%
Manufacture of wood & of products of wood & cork; except furniture; manufacture of articles of straw & plaiting materials	339	5.23%	180	53.10%
Manufacture of leather and related products	204	3.15%	101	49.51%
Manufacture of wearing apparel	397	6.12%	193	48.61%
Total of the manufacturing sector	6483		3983	61.44%

Tab 4.2.B - Sample composition of the Service sector - breakdown at a 2 digits level of economic activity				
Service Sector Activities	Number of Firms		Number of innovative firms in a Schumpeterian way	
	Count	As a percentage of the total number of firms of the service	Count	As a percentage of the total number of firms
Telecommunications	43	0.53%	38	88.37%
Insurance, reinsurance and pension funding, except compulsory social security	93	1.14%	76	81.72%
Scientific research and development	65	0.80%	50	76.92%
Financial service activities, except insurance and pension funding	487	5.97%	372	76.39%
Computer programming, consultancy and related activities	275	3.37%	210	76.36%
Architectural and engineering activities; technical testing and analysis	255	3.12%	149	58.43%
Publishing activities	99	1.21%	54	54.55%
Activities auxiliary to financial services and insurance activities	223	2.73%	121	54.26%
Accommodation	724	8.87%	375	51.80%
Wholesale trade, except of motor vehicles and motorcycles	1132	13.87%	569	50.27%
Rental and leasing activities	91	1.12%	45	49.45%
Postal and courier activities	21	0.26%	10	47.62%
Information service activities	159	1.95%	75	47.17%
Wholesale and retail trade and repair of motor vehicles and motorcycles	1128	13.82%	526	46.63%
Warehousing and support activities for transportation	347	4.25%	152	43.80%
Land transport and transport via pipelines	793	9.72%	345	43.51%
Motion picture, video and television programme production, sound recording and music publishing activities	54	0.66%	23	42.59%
Retail trade, except of motor vehicles and motorcycles	1177	14.42%	499	42.40%
Air transport	30	0.37%	12	40.00%
Water transport	64	0.78%	24	37.50%
Real estate activities	152	1.86%	54	35.53%
Food and beverage service activities	749	9.18%	193	25.77%
Total of the service sector	8161		3972	48.67%

Tab 4.3.A - "Innovative Schumpeterian" firms vs. "Innovative technological" firms in the manufacturing sector - breakdown at a 2 digits level of economic activity						
Manufactoring Sector activities	Numeber of innovative firms in a Shumpeterian way		Number of innovative firms in a narrow technological sense		Differences in the number of innovative firms according to the definition used	
	Count	As a percentage of the total number of firms	Count	As a percentage of the total number of innovative firms	Count	Percentage
Manufacture of food products	275	58.89%	158	33.83%	-117	-42.55%
Manufacture of beverages & Manufacture of tobacco products	76	70.37%	45	41.67%	-31	-40.79%
Manufacture of textiles	169	55.41%	114	37.38%	-55	-32.54%
Manufacture of wearing apparel	193	48.61%	99	24.94%	-94	-48.70%
Manufacture of leather and related products	101	49.51%	44	21.57%	-57	-56.44%
Manufacture of wood & of products of wood & cork,except furniture;manufacture of articles of straw & plaiting materials	180	53.10%	107	31.56%	-73	-40.56%
Manufacture of paper and paper products	115	60.53%	65	34.21%	-50	-43.48%
Printing and reproduction of recorded media	223	53.73%	108	26.02%	-115	-51.57%
Manufacture of coke and refined petroleum products	35	62.50%	23	41.07%	-12	-34.29%
Manufacture of chemicals and chemical products	124	83.22%	89	59.73%	-35	-28.23%
Manufacture of basic pharmaceutical products and pharmaceutical preparations	68	89.47%	47	61.84%	-21	-30.88%
Manufacture of rubber and plastic products	284	63.82%	193	43.37%	-91	-32.04%
Manufacture of other non-metallic mineral products	218	57.52%	124	32.72%	-94	-43.12%
Manufacture of basic metals	166	65.87%	85	33.73%	-81	-48.80%
Manufacture of fabricated metal products, except machinery and equipment	419	56.93%	216	29.35%	-203	-48.45%
Manufacture of computer, electronic and optical products	132	81.48%	118	72.84%	-14	-10.61%
Manufacture of electrical equipment	149	76.41%	121	62.05%	-28	-18.79%
Manufacture of machinery and equipment n.e.c.	339	74.02%	267	58.30%	-72	-21.24%
Manufacture of motor vehicles, trailers and semi-trailers	96	81.36%	74	62.71%	-22	-22.92%
Manufacture of other transport equipment	43	66.15%	30	46.15%	-13	-30.23%
Manufacture of furniture	171	60.42%	108	38.16%	-63	-36.84%
Other manufacturing	177	63.90%	113	40.79%	-64	-36.16%
Repair and installation of machinery and equipment	230	56.51%	120	29.48%	-110	-47.83%
Total of the manufactoring sector	3983	61.44%	2468	38.07%	-1515	-38.04%

Tab 4.3.B- "Innovative Schumpeterian" firms vs. "Innovative technological" firms in the service sector - breakdown at a 2 digits level of economic activity						
Service Sector Activities	Numeber of innovative firms in a Shumpeterian way		Number of innovative firms in a narrow technological sense		Differences in the number of innovative firms according to the definition used	
	Count	As a percentage of the total number of firms	Count	As a percentage of the total number of innovative firms	Count	Percentage
Wholesale and retail trade and repair of motor vehicles and motorcycles	526	46.63%	218	19.33%	-308	-58.56%
Wholesale trade, except of motor vehicles and motorcycles	569	50.27%	255	22.53%	-314	-55.18%
Retail trade, except of motor vehicles and motorcycles	499	42.40%	128	10.88%	-371	-74.35%
Land transport and transport via pipelines	345	43.51%	138	17.40%	-207	-60.00%
Water transport	24	37.50%	8	12.50%	-16	-66.67%
Air transport	12	40.00%	5	16.67%	-7	-58.33%
Warehousing and support activities for transportation	152	43.80%	50	14.41%	-102	-67.11%
Postal and courier activities	10	47.62%	6	28.57%	-4	-40.00%
Accommodation	375	51.80%	153	21.13%	-222	-59.20%
Food and beverage service activities	193	25.77%	74	9.88%	-119	-61.66%
Publishing activities	54	54.55%	32	32.32%	-22	-40.74%
Motion picture, video and television programme production, sound recording and music publishing activities	23	42.59%	11	20.37%	-12	-52.17%
Telecommunications	38	88.37%	32	74.42%	-6	-15.79%
Computer programming, consultancy and related activities	210	76.36%	168	61.09%	-42	-20.00%
Information service activities	75	47.17%	43	27.04%	-32	-42.67%
Financial service activities, except insurance and pension funding	372	76.39%	241	49.49%	-131	-35.22%
Insurance, reinsurance and pension funding, except compulsory social security	76	81.72%	52	55.91%	-24	-31.58%
Activities auxiliary to financial services and insurance activities	121	54.26%	44	19.73%	-77	-63.64%
Real estate activities	54	35.53%	14	9.21%	-40	-74.07%
Architectural and engineering activities; technical testing and analysis	149	58.43%	78	30.59%	-71	-47.65%
Scientific research and development	50	76.92%	36	55.38%	-14	-28.00%
Rental and leasing activities	45	49.45%	24	26.37%	-21	-46.67%
Total of the service sector	3972	48.67%	1810	22.18%	-2162	-54.43%

Tab 4.4.A - Types of innovations introduced by sector of economic activity													
Manufactoring Sector Activities		Product (good or service) innovations		Process innovations			Organizational innovations			Marketing innovations			
		Introduced onto the market a new or significantly improved good	Introduced onto the market a new or significantly improved service	Introduced onto the market a new or significantly improved method of production	Introduced onto the market a new or significantly improved logistic, delivery or distribution system	Introduced onto the market a new or significantly improved supporting activities	New business practices for organising work or procedures	New methods of workplace organisation	New methods of organising external relations	Significant changes to the aesthetic design or packaging	New media or techniques for product promotion	New methods for product placement or sales channels	New methods of pricing goods or services
Manufacture of food products	Count	156	42	159	71	122	105	110	50	159	101	46	55
	As a % of Innovative firms	56.73%	15.27%	57.82%	25.82%	44.36%	38.18%	40.00%	18.18%	57.82%	36.73%	16.73%	20.00%
Manufacture of beverages & Manufacture of tobacco products	Count	45	10	39	21	37	32	34	19	58	41	11	18
	As a % of Innovative firms	59.21%	13.16%	51.32%	27.63%	48.68%	42.11%	44.74%	25.00%	76.32%	53.95%	14.47%	23.68%
Manufacture of textiles	Count	104	53	98	28	81	59	58	25	44	39	19	38
	As a % of Innovative firms	61.54%	31.36%	57.99%	16.57%	47.93%	34.91%	34.32%	14.79%	26.04%	23.08%	11.24%	22.49%
Manufacture of wearing apparel	Count	94	35	69	47	87	57	68	31	78	78	47	43
	As a % of Innovative firms	48.70%	18.13%	35.75%	24.35%	45.08%	29.53%	35.23%	16.06%	40.41%	40.41%	24.35%	22.28%
Manufacture of leather and related products	Count	44	10	39	17	40	33	38	24	39	30	15	20
	As a % of Innovative firms	43.56%	9.90%	38.61%	16.83%	39.60%	32.67%	37.62%	23.76%	38.61%	29.70%	14.85%	19.80%
Manufacture of wood & of products of wood & cork,except furniture;manufacture of articles of straw	Count	101	45	110	36	84	52	77	32	47	58	21	25
	As a % of Innovative firms	56.11%	25.00%	61.11%	20.00%	46.67%	28.89%	42.78%	17.78%	26.11%	32.22%	11.67%	13.89%
Manufacture of paper and paper products 17 Manufacture of paper and paper products	Count	63	24	73	32	60	44	52	18	45	30	14	20
	As a % of Innovative firms	54.78%	20.87%	63.48%	27.83%	52.17%	38.26%	45.22%	15.65%	39.13%	26.09%	12.17%	17.39%
Printing and reproduction of recorded media	Count	91	75	149	40	92	67	98	46	50	50	23	55
	As a % of Innovative firms	40.81%	33.63%	66.82%	17.94%	41.26%	30.04%	43.95%	20.63%	22.42%	22.42%	10.31%	24.66%
Manufacture of coke and refined petroleum products	Count	22	10	13	7	18	13	18	7	10	12	7	11
	As a % of Innovative firms	62.86%	28.57%	37.14%	20.00%	51.43%	37.14%	51.43%	20.00%	28.57%	34.29%	20.00%	31.43%
Manufacture of chemicals and chemical products	Count	88	28	67	37	63	57	60	28	50	39	18	29
	As a % of Innovative firms	70.97%	22.58%	54.03%	29.84%	50.81%	45.97%	48.39%	22.58%	40.32%	31.45%	14.52%	23.39%
Manufacture of basic pharmaceutical products and pharmaceutical preparations	Count	46	8	41	20	37	35	36	26	17	16	8	13
	As a % of Innovative firms	67.65%	11.76%	60.29%	29.41%	54.41%	51.47%	52.94%	38.24%	25.00%	23.53%	11.76%	19.12%
Manufacture of rubber and plastic products	Count	189	65	174	76	156	103	135	60	70	78	30	65
	As a % of Innovative firms	66.55%	22.89%	61.27%	26.76%	54.93%	36.27%	47.54%	21.13%	24.65%	27.46%	10.56%	22.89%
Manufacture of other non-metallic mineral products	Count	118	54	116	47	103	71	88	38	65	69	27	41
	As a % of Innovative firms	54.13%	24.77%	53.21%	21.56%	47.25%	32.57%	40.37%	17.43%	29.82%	31.65%	12.39%	18.81%
Manufacture of basic metals	Count	82	33	107	38	88	64	63	29	14	26	15	28
	As a % of Innovative firms	49.40%	19.88%	64.46%	22.89%	53.01%	38.55%	37.95%	17.47%	8.43%	15.66%	9.04%	16.87%
Manufacture of fabricated metal products, except machinery and equipment	Count	198	104	248	104	202	165	206	85	89	96	41	77
	As a % of Innovative firms	47.26%	24.82%	59.19%	24.82%	48.21%	39.38%	49.16%	20.29%	21.24%	22.91%	9.79%	18.38%
Manufacture of computer, electronic and optical products	Count	116	56	68	35	70	67	60	43	42	46	28	37
	As a % of Innovative firms	87.88%	42.42%	51.52%	26.52%	53.03%	50.76%	45.45%	32.58%	31.82%	34.85%	21.21%	28.03%
Manufacture of electrical equipment	Count	119	49	94	48	82	75	81	47	51	45	22	32
	As a % of Innovative firms	79.87%	32.89%	63.09%	32.21%	55.03%	50.34%	54.36%	31.54%	34.23%	30.20%	14.77%	21.48%
Manufacture of machinery and equipment n.e.c.	Count	260	123	203	104	197	166	178	93	91	92	46	69
	As a % of Innovative firms	76.70%	36.28%	59.88%	30.68%	58.11%	48.97%	52.51%	27.43%	26.84%	27.14%	13.57%	20.35%
Manufacture of motor vehicles, trailers and semi-trailers	Count	74	24	63	31	48	60	53	34	25	22	13	13
	As a % of Innovative firms	77.08%	25.00%	65.63%	32.29%	50.00%	62.50%	55.21%	35.42%	26.04%	22.92%	13.54%	13.54%
Manufacture of other transport equipment	Count	30	12	22	11	23	27	25	22	15	14	5	12
	As a % of Innovative firms	69.77%	27.91%	51.16%	25.58%	53.49%	62.79%	58.14%	51.16%	34.88%	32.56%	11.63%	27.91%
Manufacture of furniture	Count	104	43	87	51	90	61	64	32	88	56	25	36
	As a % of Innovative firms	60.82%	25.15%	50.88%	29.82%	52.63%	35.67%	37.43%	18.71%	51.46%	32.75%	14.62%	21.05%
Other manufacturing	Count	111	51	84	44	72	56	63	40	95	56	31	38
	As a % of Innovative firms	62.71%	28.81%	47.46%	24.86%	40.68%	31.64%	35.59%	22.60%	53.67%	31.64%	17.51%	21.47%
Repair and installation of machinery and equipment	Count	95	75	60	41	105	75	126	67	20	64	25	34
	As a % of Innovative firms	41.30%	32.61%	26.09%	17.83%	45.65%	32.61%	54.78%	29.13%	8.70%	27.83%	10.87%	14.78%
Total	Count	2350	1029	2183	986	1957	1544	1791	896	1262	1158	537	809
	As a % of Innovative firms	59.00%	25.83%	54.81%	24.76%	49.13%	38.76%	44.97%	22.50%	31.68%	29.07%	13.48%	20.31%

Tab 4.4.B - Types of innovations introduced by sector of economic activity

Service Sector Activities		Product (good or service) innovations		Process innovations			Organizational innovations			Marketing innovations			
		Introduced onto the market a new or significantly improved good	Introduced onto the market a new or significantly improved service	Introduced onto the market a new or significantly improved method of production	Introduced onto the market a new or significantly improved logistic, delivery or distribution system	Introduced onto the market a new or significantly improved supporting activities	New business practices for organising work or procedures	New methods of workplace organisation	New methods of organising external relations	Significant changes to the aesthetic design or packaging	New media or techniques for product promotion	New methods for product placement or sales channels	New methods of pricing goods or services
Wholesale and retail trade and repair of motor vehicles and motorcycles	Count	119	189	95	79	195	168	234	124	73	265	123	132
	As a % of Innovative firms	22.62%	35.93%	18.06%	15.02%	37.07%	31.94%	44.49%	23.57%	13.88%	50.38%	23.38%	25.10%
Wholesale trade, except of motor vehicles and motorcycles	Count	202	168	112	144	234	221	296	167	154	276	152	165
	As a % of Innovative firms	35.50%	29.53%	19.68%	25.31%	41.12%	38.84%	52.02%	29.35%	27.07%	48.51%	26.71%	29.00%
Retail trade, except of motor vehicles and motorcycles	Count	77	98	58	81	153	146	225	110	149	330	157	200
	As a % of Innovative firms	15.43%	19.64%	11.62%	16.23%	30.66%	29.26%	45.09%	22.04%	29.86%	66.13%	31.46%	40.08%
Land transport and transport via pipelines	Count	55	130	64	101	147	104	182	116	39	102	34	74
	As a % of Innovative firms	15.94%	37.68%	18.55%	29.28%	42.61%	30.14%	52.75%	33.62%	11.30%	29.57%	9.86%	21.45%
Water transport	Count	4	6	8	5	9	7	13	7	2	8	7	10
	As a % of Innovative firms	16.67%	25.00%	33.33%	20.83%	37.50%	29.17%	54.17%	29.17%	8.33%	33.33%	29.17%	41.67%
Air transport	Count	3	5	5	5	4	5	7	8	3	6	5	6
	As a % of Innovative firms	25.00%	41.67%	41.67%	41.67%	33.33%	41.67%	58.33%	66.67%	25.00%	50.00%	41.67%	50.00%
Warehousing and support activities for transportation	Count	18	49	32	35	71	61	90	49	21	40	19	24
	As a % of Innovative firms	11.84%	32.24%	21.05%	23.03%	46.71%	40.13%	59.21%	32.24%	13.82%	26.32%	12.50%	15.79%
Postal and courier activities	Count	3	6	4	5	4	8	8	4	2	5	1	4
	As a % of Innovative firms	30.00%	60.00%	40.00%	50.00%	40.00%	80.00%	80.00%	40.00%	20.00%	50.00%	10.00%	40.00%
Accommodation	Count	72	148	67	36	106	60	125	90	104	236	116	239
	As a % of Innovative firms	19.20%	39.47%	17.87%	9.60%	28.27%	16.00%	33.33%	24.00%	27.73%	62.93%	30.93%	63.73%
Food and beverage service activities	Count	48	56	51	30	67	42	81	37	56	89	27	58
	As a % of Innovative firms	24.87%	29.02%	26.42%	15.54%	34.72%	21.76%	41.97%	19.17%	29.02%	46.11%	13.99%	30.05%
Publishing activities	Count	31	23	24	14	26	18	25	15	27	24	19	12
	As a % of Innovative firms	57.41%	42.59%	44.44%	25.93%	48.15%	33.33%	46.30%	27.78%	50.00%	44.44%	35.19%	22.22%
Motion picture, video and television programme production, sound recording and music publishing	Count	5	10	2	0	8	3	7	8	0	9	3	8
	As a % of Innovative firms	21.74%	43.48%	8.70%	0.00%	34.78%	13.04%	30.43%	34.78%	0.00%	39.13%	13.04%	34.78%
Telecommunications	Count	15	32	14	9	14	20	26	14	11	17	13	18
	As a % of Innovative firms	39.47%	84.21%	36.84%	23.68%	36.84%	52.63%	68.42%	36.84%	28.95%	44.74%	34.21%	47.37%
Computer programming, consultancy and related activities	Count	127	147	92	37	103	105	133	92	35	65	47	44
	As a % of Innovative firms	60.48%	70.00%	43.81%	17.62%	49.05%	50.00%	63.33%	43.81%	16.67%	30.95%	22.38%	20.95%
Information service activities	Count	17	41	21	13	38	27	49	24	12	14	11	20
	As a % of Innovative firms	22.67%	54.67%	28.00%	17.33%	50.67%	36.00%	65.33%	32.00%	16.00%	18.67%	14.67%	26.67%
Financial service activities, except insurance and pension funding	Count	175	225	158	110	217	199	284	181	151	208	108	147
	As a % of Innovative firms	47.04%	60.48%	42.47%	29.57%	58.33%	53.49%	76.34%	48.66%	40.59%	55.91%	29.03%	39.52%
Insurance, reinsurance and pension funding, except compulsory social security	Count	45	43	37	21	40	52	51	40	37	32	26	22
	As a % of Innovative firms	59.21%	56.58%	48.68%	27.63%	52.63%	68.42%	67.11%	52.63%	48.68%	42.11%	34.21%	28.95%
Activities auxiliary to financial services and insurance activities	Count	30	38	24	10	46	40	83	36	19	49	32	23
	As a % of Innovative firms	24.79%	31.40%	19.83%	8.26%	38.02%	33.06%	68.60%	29.75%	15.70%	40.50%	26.45%	19.01%
Real estate activities	Count	10	10	5	8	21	15	30	14	7	22	10	12
	As a % of Innovative firms	18.52%	18.52%	9.26%	14.81%	38.89%	27.78%	55.56%	25.93%	12.96%	40.74%	18.52%	22.22%
Architectural and engineering activities; technical testing and analysis	Count	27	73	52	18	64	54	82	43	9	33	14	25
	As a % of Innovative firms	18.12%	48.99%	34.90%	12.08%	42.95%	36.24%	55.03%	28.86%	6.04%	22.15%	9.40%	16.78%
Scientific research and development	Count	28	27	27	8	24	18	30	17	3	8	3	5
	As a % of Innovative firms	56.00%	54.00%	54.00%	16.00%	48.00%	36.00%	60.00%	34.00%	6.00%	16.00%	6.00%	10.00%
Rental and leasing activities	Count	13	22	9	6	23	16	20	10	12	23	12	15
	As a % of Innovative firms	28.89%	48.89%	20.00%	13.33%	51.11%	35.56%	44.44%	22.22%	26.67%	51.11%	26.67%	33.33%
Total	Count	1124	1546	961	775	1614	1389	2081	1206	926	1861	939	1263
	As a % of Innovative firms	28.30%	38.92%	24.19%	19.51%	40.63%	34.97%	52.39%	30.36%	23.31%	46.85%	23.64%	31.80%

Tab 4.5.A - Average number of innovative activities performed by each innovative firm in the manufactoring sector					
Manufactoring Sector activities	Product (good or service) innovations	Process innovations	Organizational innovations	Marketing innovations	Oveall
Manufacture of food products	0.72	1.28	0.96	1.31	4.28
Manufacture of beverages & Manufacture of tobacco products	0.72	1.28	1.12	1.68	4.80
Manufacture of textiles	0.93	1.22	0.84	0.83	3.82
Manufacture of wearing apparel	0.67	1.05	0.81	1.27	3.80
Manufacture of leather and related products	0.53	0.95	0.94	1.03	3.46
Manufacture of wood & of products of wood & cork,except furniture;manufacture of articles of straw & plaiting materials	0.81	1.28	0.89	0.84	3.82
Manufacture of paper and paper products 17 Manufacture of paper and paper products	0.76	1.43	0.99	0.95	4.13
Printing and reproduction of recorded media	0.74	1.26	0.95	0.80	3.75
Manufacture of coke and refined petroleum products	0.91	1.09	1.09	1.14	4.23
Manufacture of chemicals and chemical products	0.94	1.35	1.17	1.10	4.55
Manufacture of basic pharmaceutical products and pharmaceutical preparations	0.79	1.44	1.43	0.79	4.46
Manufacture of rubber and plastic products	0.89	1.43	1.05	0.86	4.23
Manufacture of other non-metallic mineral products	0.79	1.22	0.90	0.93	3.84
Manufacture of basic metals	0.69	1.40	0.94	0.50	3.54
Manufacture of fabricated metal products, except machinery and equipment	0.72	1.32	1.09	0.72	3.85
Manufacture of computer, electronic and optical products	1.30	1.31	1.29	1.16	5.06
Manufacture of electrical equipment	1.13	1.50	1.36	1.01	5.00
Manufacture of machinery and equipment n.e.c.	1.13	1.49	1.29	0.88	4.78
Manufacture of motor vehicles, trailers and semi-trailers	1.02	1.48	1.53	0.76	4.79
Manufacture of other transport equipment	0.98	1.30	1.72	1.07	5.07
Manufacture of furniture	0.86	1.33	0.92	1.20	4.31
Other manufacturing	0.92	1.13	0.90	1.24	4.19
Repair and installation of machinery and equipment	0.74	0.90	1.17	0.62	3.42
Total	0.85	1.29	1.06	0.95	4.14

Tab 4.5.B - Average number of innovative activities performed by each innovative firm in the service sector					
Service Sector activities	Product (good or service) innovations	Process innovations	Organizational innovations	Marketing innovations	Oveall
Wholesale and retail trade and repair of motor vehicles and motorcycles	0.59	0.70	1.00	1.13	3.41
Wholesale trade, except of motor vehicles and motorcycles	0.65	0.86	1.20	1.31	4.03
Retail trade, except of motor vehicles and motorcycles	0.35	0.59	0.96	1.68	3.58
Land transport and transport via pipelines	0.54	0.90	1.17	0.72	3.33
Water transport	0.42	0.92	1.13	1.13	3.58
Air transport	0.67	1.17	1.67	1.67	5.17
Warehousing and support activities for transportation	0.44	0.91	1.32	0.68	3.35
Postal and courier activities	0.90	1.30	2.00	1.20	5.40
Accommodation	0.59	0.56	0.73	1.85	3.73
Food and beverage service activities	0.54	0.77	0.83	1.19	3.33
Publishing activities	1.00	1.19	1.07	1.52	4.78
Motion picture, video and television programme production, sound recording and music publishing activities	0.65	0.43	0.78	0.87	2.74
Telecommunications	1.24	0.97	1.58	1.55	5.34
Computer programming, consultancy and related activities	1.30	1.10	1.57	0.91	4.89
Information service activities	0.77	0.96	1.33	0.76	3.83
Financial service activities, except insurance and pension funding	1.08	1.30	1.78	1.65	5.81
Insurance, reinsurance and pension funding, except compulsory social security	1.16	1.29	1.88	1.54	5.87
Activities auxiliary to financial services and insurance activities	0.56	0.66	1.31	1.02	3.55
Real estate activities	0.37	0.63	1.09	0.94	3.04
Architectural and engineering activities; technical testing and analysis	0.67	0.90	1.20	0.54	3.32
Scientific research and development	1.10	1.18	1.30	0.38	3.96
Rental and leasing activities	0.78	0.84	1.02	1.38	4.02
Total	0.67	0.84	1.18	1.26	3.95