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**The impact of technological and organizational innovations on firms' performance:
Is there a difference between manufacturing and service sectors?**

Rinaldo Evangelista

University of Camerino (IT)
rinaldo.evangelista@unicam.it;

and

Antonio Vezzani

University of Rome Tor Vergata
antonio.vezzani@uniroma2.it

Abstract

By using firm level data provided by the last round of the (Italian) Community Innovation Survey (CIS4) this paper explores (in a manufacturing-services comparative framework) the relationship between technological and non-technological innovation and their impact on firms' performances. The empirical evidence presented shows that including the organizational dimension of innovation provides a much more comprehensive picture of the variegated universe of innovation in both macro sectors. Four distinct innovation modes have been identified on the basis of the ways firms combine technological and non-technological innovations. These different modes of innovation are present and relevant in both manufacturing and service sectors and have been found to have a differentiated impact on firms' performances. Strategies characterized by the joint introduction of product, process and organizational innovations have been found to give to both manufacturing and service firms a clear competitive advantage vis à vis both non innovating firms and firms with a narrow approach to innovation. A few significant differences between services and manufacturing firms in the relevance and economic impact of different types of innovation strategies have also been found.

Keywords: technology, organizational innovation, economic performance

1. Introduction

It is a well known fact that most of the literature which over the last few decades has investigated the economic impact of technological change has been characterized by a sort of manufacturing focus/bias. In fact, services have been for a long time considered as technologically backward, with innovation playing only a marginal (or even negative) role in explaining the aggregate performance of this sector and the competitive strategies of firms. Over the last decade a new stream of contributions has started to challenge this view (Miles, 1995; Miles et al., 1995; Gadrey and Gallouj, 1998; Andersen et al., 2000; Metcalfe and Miles, 2000; Tether, 2003). Although more is known about the relevance of innovation in services, its economic impact has been investigated to a very limited extent, particularly at the firm level. This gap in the literature can to some extent be explained by the difficulty of accessing micro-data, which in the case of services is even greater. There are also data constraints and methodological problems related to the availability of appropriate indicators to measure innovation in services, which should be extended beyond a pure technological domain. Organisational change is perhaps the most important form of non-technological innovation, but also the more difficult to be grasped both on conceptual and on an empirical ground. Despite there is a large amount of (mostly qualitative and anecdotic) literature emphasising the role that non-technological types of innovation play in services, very little is known about the extent to which these types of innovations are complements or substitutes of technological innovations, the relative importance of technological and organizational changes as drivers of firms' economic performances and whether there are differences in the relevance and economic impact of these two different forms of innovations. This paper tries precisely to investigate these points using firm-level data provided by the last round of the Community innovation Survey (CIS4).

The paper is structured as follows: the next section highlights some problematic issues emerging once the analysis of the innovation-performance relationship is extended to services and organizational innovations, while section three contains some methodological notes along with a discussion on the strengths and weaknesses of CIS data with reference to the research issues addressed in this paper. The empirical section is composed of two main parts. In section four, the existence, relevance and internal consistency of distinct innovation modes, made of different combinations of technological (product/process) and non-technological innovations is investigated. In the following section the impact of these different *innovation modes* on firm's economic performances in both manufacturing and service industries is empirically assessed

through an econometric firm level estimation. The concluding section summarizes the main findings and draws some methodological implications for future research.

2. Extending the analysis of the innovation- performance relationship to services: open issues

Over the last decade there have been increasing efforts to investigate the economic impact of innovation, especially at a firm level. The widespread interest in micro-level studies in this research field is justified by several reasons, the most important being the diffused dissatisfaction towards aggregated analyses which are perceived to be unable to grasp the heterogeneity of firms' innovative behaviours as well as the different technological sources of firms' competitiveness. An attempt has also been made to go beyond the linear and R&D centred vision of the innovation process and its effects on performances with the use of more comprehensive measures of firm's innovation inputs, activities and outputs. CIS data have been increasingly used in this new body of empirical research with most of these contributions following the so-called MCD model, first presented in a seminal contribution by Crepon, Duguet and Mairesse in 1998 (Crepon et al. 1998).¹ Also in this new - largely micro-oriented - stream of empirical research Services have been an under-investigated area, the majority of analyses being still very much focussed on the manufacturing sectors.² Over the last few years some empirical attempts have nonetheless been made in order to explore the effects of innovation on the economic performances of services firms or, at least, services industries have started to be covered along with manufacturing ones (Cainelli et al., 2006; Lööf and Heshmati, 2006; van Leeuwen and Klomp, 2006; Abreu et al., 2008; Castellacci and Zheng, 2008). Still, in most of this empirical literature, the issue regarding if, and the extent to which, approaches and indicators traditionally used for studying the innovation-performance relationship in the manufacturing domain could be used in Services has not been properly tackled, somewhat ignoring a substantial body of literature that over the last few years has been duelling on what really is, and how should be measured, innovation outside the manufacturing world. In fact, by using data referring to the core section of CIS questionnaire, these studies explicitly or implicitly adopt a "technological

¹ The main effort to exploit, in a cross country comparative framework, CIS micro-data that is now under way has been led by the OECD that has organised a project on the determinants of productivity, and asked national teams of researchers with access to national data to carry out the empirical tests using a common econometric regression model (C-D-M). A synthesis of the main result of this project is contained in OECD, 2008.

² As far as studies using CIS data are concerned, this is due to persisting data constraints (for many services sectors micro data are not yet available) and to the fact that, according to some scholars, this type of survey is not fully suited to grasp the specific nature of innovation activities in services and consequently also its economic impact (Tether, 2008).

conceptualisation” of innovation activities. In this manufacturing-based perspective, the distinction between product and process innovation plays (explicitly and more often implicitly) a fundamental role being able (to a considerable extent) to discriminate between different types of strategies and different effects on performances (Simonetti et al., 1995; Edquist et al., 2001; Bogliacino and Pianta, 2009).

Figure 1 shows, in a very stylised and simplified way, the diversified effects of product and process innovations on different *dimensions* and *sources* of firms’ performances. Product innovations are expected to provide firms with a competitive advantage via the technological novelty and improved performances of the product. Alternatively, process innovations provide a competitive advantage via the efficiency/productivity gains obtained through the introduction of more performing ways of producing (pre-existing) products. In a Schumpeterian perspective of the selection mechanism, both product and process innovation should in turn give a competitive premium in terms of above average growth rates and market share gains.

(Figure 1 around here)

Of course the distinction between product and process innovations should not be overemphasised. These two types of innovations are often closely interrelated and their effects on performances difficult to be disentangled. In fact, productivity gains might be expected also in the case of product innovations, when obsolete commodities are substituted by new products which satisfy similar consumer needs at a lower cost. In the same vein, the introduction of process innovations might be accompanied by some improvement in the quality content and performance of the product. Despite these blurred boundaries there is a certain amount of evidence showing that the distinction between product and process innovation is still effective to identify the “dominant” type of strategy pursued by firms in the different industries and technological regimes (Pavitt, 1984; Evangelista, 1999; Edquist et al., 2001; Crespi and Pianta, 2008).

The conceptual framework sketched in Figure 1, based on the contrasting nature and effects of product and process related innovation activities, is clearly drawn from our understanding of innovation in the manufacturing industry. When this framework, and the empirical analysis of the innovation-performance relationship, are extended to Services three main complications emerge: a) the first one is related to relevance and effectiveness – in the case of service industries

- of the traditional distinction between product and process innovation; b) a second complication is connected to the need of broadening the concept of innovation beyond the technological domain; c) the third one is related to the difficulties of measuring economic outputs and performances (productivity) in many service industries. These points are discussed in more detailed below.

a) The question of whether and the extent to which the traditional conceptual tool box used for analysing innovation in the manufacturing sectors can be used in the service sector is, in fact, the object of a lively debate (Gallouj, 2002; Drejer, 2004; Evangelista, 2006; Tether, 2005, Tether and Tajar, 2008). Scholars following the so called “demarcation approach” argue that the co-terminality between production and consumption characterizing most service activities makes the distinction between product and process innovations less clear-cut, or even meaningless, in services, while the “assimilation approach” tends to minimise the differences between manufacturing and service industries in the fundamental knowledge assets and types of innovation activities carried out by firms. Over the last few years this polarization has been somewhat overcome by a more balanced perspective arguing that “...services and manufactures do not follow entirely different approaches to innovation, but that studies of services and their innovation activities (such as those undertaken in the demarcation tradition) bring to the fore neglected aspects of the innovation process, which although most prominent in services, are (increasingly) widely distributed throughout the economy” (Tether, 2005, p. 156). In such a “synthesis perspective” the answer to the question regarding the applicability of the product/process distinction to services is probably “yes”, although not as much as in the manufacturing sector, and not to the same extent in all service industries (Evangelista, 2006). There is however still very little systematic evidence validating and qualifying such a statement.

b) Despite the need of broadening the technological boundaries of innovation is widely felt as a very relevant issue in the case of both manufacturing and service industries, it is with reference to the latter sectors that this step ahead is considered absolutely vital. One of the most stressed peculiarities of innovation in services has to do in fact with the dominant role played by non-technological types of knowledge assets, competencies and strategies. This has clear implications for the analysis and the empirical investigation of the impact of innovation on firms’ economic performances. With reference to the scheme presented in Figure 1, and confining the discussion to the role and impact of organizational innovation, the following question marks emerge: Do these types of innovations represent a third autonomous innovation mode or are they

complements to product or process innovations (and related strategies)? What are their (individual or combined) effects on firms' economic performances? Are they introduced in order to reduce production costs, foster productivity or increasing the performances and quality content of the products and services? Also on these points the empirical literature is still scant and fragmented and part of the difficulties of exploring this phenomenon has to do with the multiform dimension of firms' "organizations" and the high firm and industry level heterogeneity in firms organizational strategies and assets (Brynjolfsson and Hitt, 2000; Bresnahan et al. 2002; Armbuster et al, 2006). Existing studies, although with different approaches and data, seem to indicate that technological and non technological innovation are complements rather than substitutes. Other studies emphasise the co-existence, both in manufacturing and service industries, of different innovation modes characterised by different mixes of product, process and non-technological innovations (Hollenstein, 2003; OECD, 2008; Tether and Tajar, 2008) and that better economic performance are usually associated to more complex or systemic types of strategies (Hitt, 2000; Bresnahan et al., 2002; Gera and Gu, 2004). All in all, the empirical evidence emerging from the studies which have extended the analysis of innovation (and its impact) beyond the technological domain should be considered very preliminary, and somehow affected by the crude definition and indicators of organizational innovation adopted. Much more conceptual and empirical work will be needed in order to validate, consolidate (or even confute) these types of findings.

c) Last but not least, finding appropriate and effective measures of economic performances is, in the case of services, more difficult than for manufacturing industries, and this creates a further complication (in addition to *a*) and *b*) above) for any empirical assessment of the innovation-performance relationship. This is in turn due to several features of services activities which make problematic the same identification and measurement of the economic output of services, the latter being the basis of any measure of firms' economic performance, and more in particular to any indicator of productivity. The potential mis-measurement of real output and productivity of services is still at stake since the issue was raised in a comprehensive work by Griliches (1992), as shown by Djellal and Gallouj (2007). The definition of the production unit, the use of an appropriate price deflator to obtain real figures, the inclusion of quality effects to adjust price deflators, the difficulties of including total production factors — rather than labour only — to obtain productivity indicators for services are some of the issues which have to be taken into account to measure the economic and particularly the productivity impact of innovation.

The problematic points briefly discussed above raise a set of crucial issues which still need to be properly investigated and answered on the basis of robust methodologies and empirical evidence. This paper tries to provide a contribution in this direction using firm level data provided by the Italian CIS.

3. Data and methodology

In this paper data drawn from the fourth round of the Italian CIS (CIS4) - referring to the period 2002-2004 - are used. CIS collects data on a wide range of aspects related to firms' innovation activities and performances. Firms are in fact asked about the type of innovation introduced over the three years period covered by the survey, the specific innovation activities carried out in the same period, the expenditures and human resources dedicated to such activities plus a set of more qualitative information about the sources of information, the objectives pursued and the hampering factors associated to the innovation process. A major strength of CIS is that it collects data for very large samples of firms, representative of all manufacturing and service industries across Europe. The survey is carried out every four years and data of the different waves could (at least in principle) be matched longitudinally and linked to business-registered data in order to study the innovation process and its economic effects in a dynamic framework. Such possibility has however been exploited only to a limited extent due to several types of data and methodological constraints faced by the different national statistical offices in linking different data-sources and making these integrated firm-level datasets available for empirical research.

Despite being still very much focused on technological innovation, CIS4 has made a step forward - compared to previous CIS waves - in the measurement of non-technological innovation. European firms have in fact been asked whether they had: a) "implemented new or significantly improved management systems", b) "made a major change to the organisation of work within the enterprise, such as changes in the management structure or integrating different departments or activities; c) introduced new or significant changes in the relations with other firms, such as alliances, partnership, outsourcing and sub-contracting; d) made significant changes to the design or packaging of a good or service; e) introduced new or significantly changed sales methods or distributions channels, such as internet sales, franchising, direct sales, or distribution licences. In addition, firms have been asked to assess the effects of such changes and namely on f) "the time needed to respond to customer", g) "the quality of the products and services", h) "production costs" and i) "employee satisfaction and turnover".

Of course these are rather gross (and somehow arbitrary) definitions of non-technological innovations, and this is true particularly with reference to a complex and multifaceted phenomenon such as organizational change. Nonetheless, given the limited availability of other large-scaled surveys combining data on both technological and organizational innovation, an in-depth firm-level exploration of CIS4 is expected to provide some preliminary insights on the locus, relevance and economic impact of both technological and organisational innovations in both manufacturing and service sectors.

In our empirical analysis we will combine the binary variables signalling the presence and effects of organizational (positive answer to at least one of the questions a, b and c above) and marketing (positive answer to at least one of the questions d and e) innovations with a few variables and indicators drawn from the core “technological” section of the CIS questionnaire, and namely those indicating the specific type of technological innovation introduced (product/process) along with a set of indicators able to highlight the innovation profile and strategy associated to different mixes of technological and non-technological innovations.

The economic impact of innovation will be measured using a very simple “growth” performance indicator that is the rate of growth of turnover during the three years covered by the CIS. This choice was somewhat dictated by the limited set of economic variables collected by CIS4 (number of employees and turnover respectively in 2002 and 2004). We avoided to use the “turnover per employ” ratio since, as already pointed out, this indicator is likely to be - especially in the case of services - a too crude and biased proxy of labour productivity (Griliches, 1992; Wölfl, 2004). We also think that the “growth of turnover” indicator is rather consistent with a Schumpeterian-evolutionary perspective of the innovation-performance relationship and with what should be the ultimate economic outcome of an innovation-fuelled competitive-selection process. In line with what envisaged in Figure 1 productivity might be conceived more as a source of competitiveness rather than an exhaustive measure of it. Furthermore, as already pointed out, innovation might provide a competitive advantage to firms also independently from efficiency/productivity gains. This again supports our choice to investigate the innovation-performance relationship using as a much broader and comprehensive indicator of firm competitiveness such as the actual rate of growth experienced by firms over a three year period. A more detailed description of the CIS-based indicators used in the empirical analysis is contained in Table 1. The CIS4 data-set used in this empirical exercise is made of a stratified sample representative of all Italian manufacturing and service firms with more than 9 employees. All the statistical and econometric analyses have been performed using *un-weighted* firm-level

data with the exception of the descriptive figures shown in Table 4 (relevance of the different innovation modes across industries) which have been computed using *weighting factors* provided by the Italian statistical office (Istat).

Before describing the empirical findings of our analysis it is worth discussing two typical econometric issues arising when CIS data, drawn from one single wave, are used for estimating the innovation-performance relationship. These issues are (i) the causality direction between innovation and economic performance variables and (ii) the potential bias related to the sample selection problem, discussed in some more detail below.

i) The cross sectional nature of CIS data constrains the possibility of using a proper lag structure between innovation and economic performance indicators and test for Granger causal links. Data are on the contrary adequate to conduct a sound test for the existence of structural associations between innovation and economic performance indicators. However, we believe that these structural associations might reveal the presence of cumulative and two ways linkages between innovation and economic performance. In other words, in order to give to the results of our econometric estimations a cause-effect interpretation, we start from a “viscosity” assumption, referred to both the innovation activities and to the innovation performance relationship. This assumption, far from being an easy and ad-hoc short cut used to give econometric robustness to our results, is indeed grounded within a substantial body of both theoretical and empirical literature, highlighting the cumulative and self-reinforcing nature of the innovation-performance relationship (Nelson and Winter, 1982, Dosi, 1988; Dosi and Nelson, 1994, Cainelli et al., 2005). Starting from this assumption, our estimated *beta* coefficients are assumed to capture - more than short term cause-effects relationships - persistent asymmetries in the innovation capabilities of firms, which in turn are able to explain differences in their long term performances. What we do with our analysis is verifying the role and effectiveness of different types of innovation strategies in generating long lasting asymmetries among firms and in fuelling a dynamic self-reinforcing mechanism between innovation and economic performances.

ii) Due to the structure of the CIS questionnaire, some variables (those innovative ones) are available only for firms which have introduced at least a product or a process innovation. This creates a potential selection bias if the econometric analysis is restricted to this sub-sample of firms which is likely to be not randomly drawn from the larger population. This type of bias produces distorted coefficients. Our estimation strategy (and the choice of variables used) allows us to include all the firms present in the CIS sample, avoiding the problem of the selection bias.

(Table 1 around here)

4. Looking for “innovation modes” in manufacturing and service industries

The term “innovation modes” broadly refers to the possibility of synthesising (in an effective way) the highly heterogeneous nature of firms’ innovative behaviours in a manageable and interpretable set of typologies of innovation practices, strategies and performances. Different methodologies, indicators and datasets have been used to identify such innovation modes (see for instance Tether, 2001; Hollenstein, 2003; Arundel and Hollander, 2005; EUROSTAT, 2008). The most common practice consists of starting from a very large set of indicators and samples of firms, which are then respectively synthesized in a reduced number of key dimensions and groups of firms through multivariate techniques such as principal component and cluster analyses.

In this work “innovation modes” are identified in a rather simple way taking into account only the innovation output of firms and, more in particular, the type of innovation introduced by firms, distinguishing between those which have a technological content (product/process) and those which fall beyond the technological domain (organizational and marketing innovations). On the basis of the questions included in the CIS questionnaire (see *a*) to *e*) question listed in previous section) a cluster analysis was carried out using eight variables, four referring to the introduction of a technological innovation (only product, only process, product and process, none) and four referring to non-technological innovation (only organizational, only marketing, organizational and marketing, none). The joint consideration of all these variables produces (once non-innovator at all are excluded) fifteen possible combinations (mixes) of firms’ innovation outputs.

The cluster analysis has delivered four main groups of firms, differing from each other on the basis of the relevance played by different types of technological and non-technological innovations. In order to interpret, check the internal consistency, and better qualify these clusters as distinct *innovation modes* we can look respectively at Table 2 and 3. Table 2 shows the distribution of firms in each cluster according to the type of innovation introduced while Table 3 presents the results of four probit estimations which relate the probability for belonging to each

specific cluster to a set of CIS indicators grasping different dimensions of firms innovative behaviours and performances. Along with a set of control variables, among the regressors a set of indicators which could broadly be associated to process or product oriented innovation strategies have been included and namely those measuring: a) the importance attached to different effects related to the innovation introduced (both technological and non-technological); b) the share of turnover related to the new products or services c) the share of innovation expenditures devoted to the acquisition of new machinery and equipment; d) the overall innovation performances of firms as measured by the total financial resources devoted to innovation (total innovation expenditures per employee) (see Table 1 for a detailed description of the indicators used in the probit estimates).

(Tables 2 and 3 around here)

On the basis of the data and evidence presented in Table 2 and 3, the four clusters can be interpreted as distinct *innovation modes* and their characteristics described as follows:

- 1) *Product oriented*: this innovation mode is followed by 1073 firms (13.06% of the innovative firms). These firms have introduced only product innovation often accompanied with a marketing one. Firms belonging to this sort of “pure” product innovation mode attach little importance to “cost reduction strategies”; the product orientation of their innovation activities is confirmed by the importance attached to objectives such as increasing the range of goods or services, enter in new markets or increase market share and improve quality of goods or service as well as by the relatively high share of sales related to new or improved products and services.
- 2) *Process oriented*: this cluster consists of 2192 firms introducing process innovation along with organisational and marketing one. The process orientation of the innovation activities carried out by firms in this cluster is confirmed by the importance attached to process-related objectives, the negative association to product related objectives and the positive association with the acquisition of equipment and computer hardware or software to produce new or significantly improved processes. The probit estimations suggest that firms in this group tend to be poor innovators as confirmed to the negative sign associated to the variable “innovation expenditures per employee). The labour saving nature of the innovation strategies carried out by these firms seems to be confirmed by the negative relation with the “job satisfaction” indicator.
- 3) *Organisational*: this innovation mode is, surprisingly, the most relevant one with all 2893 firms introducing some type of organizational change sometime accompanied with a process innovation. Unfortunately, the limited set of information provided by CIS on firms introducing

(only) non-technological innovations does not allow us to fully explore the underlying strategies characterizing this innovation mode. Nonetheless an interesting finding is that firms relying exclusively on the introduction of an organizational innovation tend to attach more importance (compared to the other firms) to objectives such as the “reduction of the time needed to respond to customer or supplier needs” and of “improvement of the quality of goods or services” while no association is found with the objective of “reducing the cost for unit of output”. These results suggest that in this innovation mode organizational changes are a complement to, or a prerequisite for, the improvement of the qualitative content and performance of pre-existing products and services.

4) *Complex*: this innovation mode is followed by the very dynamic and technologically innovative firms whose distinctive feature is the adoption of a systemic approach to innovation. Firm size is above the average as well as the amount of resources devoted to innovation and the share of turnover related to the introduction of new or improved products/services. Firms in this cluster introduce both product and process innovation along with changes in the organisational structure and the implementation of innovative marketing strategies. The complex and systemic nature of this innovation mode is further confirmed by the fact that firms regard as highly important both product and process related effects of technological innovation. Also for this group of firms organizational changes seem to reflect (or support) a product oriented and quality enhancement orientation of innovation activities rather than following a cost-reduction rationale.

The four innovation modes described above have been singled out pulling together data for both manufacturing and service firms. An important aspect to be investigated is the possible presence of differences between these two macro-sectors in the relevance and profile of these four innovation modes. Indications on both aspects can be drawn by looking at the distribution of firms across the different innovation modes within the two major branches of the economy (Table 4) and by replicating the probit regressions separately for manufacturing and service firms (Table 5).

All in all the results of this comparative exercise show that the four innovation modes are present and relevant in both macro sectors and that no macroscopic differences between the manufacturing and service sectors emerge in the profile and characterization of these four different types of innovation strategies. Nonetheless a closer look at the evidence presented allows us to identify a few differences, which are worth to be pointed out:

a) The *Product oriented innovation mode* is more relevant in the manufacturing sector than in it is in services industries (15.8% vs 11.8% of firms) and within the manufacturing sector Science based industries have the highest share of (mainly small and medium sized) firms pursuing this type of strategy (26.7%). Also the *Process oriented innovation mode* is slightly over-represented in the manufacturing industries (32.4% vs 30.4%). In both macro-sectors firms pursuing pure process oriented strategies are dominant in the most traditional and scale intensive sectors.

As expected, the *Organisational mode* is particularly relevant in the services sector where 38.9% (against a 27.6% found in the manufacturing sector) of innovators follow this type of strategy. In all service branches this is the most common and dominant innovation mode while within the manufacturing sectors the share of firms relying on a pure organizational approach is particularly relevant in the scale intensive industries. The *Complex mode* is more relevant in the manufacturing industry than it is in services (24.2% vs 19%). In both macro-sectors this innovation mode is particularly important among the most innovative industries: more than 40% of firms in the Science based and Specialized supplier industries are complex innovators; within services this innovation mode is the second more widespread innovation mode (behind the organizational one).

(Tables 4 and 5 around here)

5. The impact of technological and organizational innovations on economic performances

In the previous section we have identified four different innovation modes and checked their relevance and consistency across sectors. The next and final step consists of assessing the impact that these different innovation modes on firms performances and checking if, also in this respect, significant differences between manufacturing and service industries emerge. Following the conceptual framework and linkages sketched in Figure 1 the following equation is estimated:

$$\Delta Y_{it} = \alpha + \sum_{j=1}^4 \phi_j cluster + \beta_1 herfindal_{t-1} + \beta_2 prod02_{it-1} + \beta_3 lemp02_{it-1} + \beta_4 mkt_size_i + \beta_5 h_dem_i + \varepsilon_{it}$$

where ΔY_{it} denotes the rate of growth of sales of firms between 2002 and 2004; the innovation modes, the variables of interest, are denoted with *cluster*; *prod02* is a measure of labour productivity in 2002, *lemp02* is the natural logarithm of employees in 2002, *herfindal* and

mkt_size are indicators of market competition (proxied by the Herfindahl³ index and the size of the relevant market), while *h_dem* (importance of the lack of demand for innovative products as an obstacle to innovate) aims at capturing the presence (lack of) a demand-pull mechanism . A set of industry dummies calculated on the SIC 2-digit level, have also been included.

Similarly to the previous section we first estimate the equation using data referring to the whole sample; then the analysis is replicated taking into account manufacturing and service sectors separately. Specific estimations will also be carried out in a sub-set of service and manufacturing macro-sectors in order to investigate whether different innovation strategies have different economic effects across different groups of industries. Results of the estimations are reported in Tables 6 and 7.

(Table 6 around here)

The results of the estimation carried out on the whole sample (Table 6 - column 1), confirms that innovation lies at the very heart of the competitive process.⁴ In fact, all the innovation modes are associated to the “growth of turnover” indicator with positive and significant coefficients. Among the different possible strategies the “complex” one has the strongest impact on firms’ economic growth, while strategies merely based on the introduction of product or process innovation are the least effective. An interesting finding emerging from Table 6 is the very important role of strategies characterized by the introduction of pure organizational innovation (organizational mode). This result confirms once again that changes in the organizational structure and operational functioning of firms might represent an autonomous and effective, innovation mode, and that such an innovation strategy appears to be more rewarding than pure product or process oriented strategies.

³ The Herfindahl index is a measure of the degree of competition among firms and is calculated as the sum of square of firms' market share.

⁴ The explanatory power of the equation estimated is rather low but this does not come as an unexpected result, especially when the characteristics of both the data-set and the indicators used are taken into account. The low R_squared coefficients obtained are in fact rather consistent with similar econometric exercises which have used CIS firm-level data. In our specific case the limited amount of variance explained by the model can be associated to the following factors: a) the highly heterogeneous nature of firms characteristics, behaviours and performances; b) the subjective, dycotomic and gross nature of the indicators used to grasp such heterogeneity; c) the very large and erratic variance characterizing our dependent variable (“rate of growth of turnover”), when the latter is observed at the firm level and within a short time span (three years). Despite these caveats our estimations produce significant *b coefficients* (for most of our regressors), which are worth to be interpreted in the light of the specific research objectives of this paper.

Some similarities and important differences between manufacturing and service industries come out once we compare the results obtained running separate estimations on the two sub-samples of firms (Columns 2 and 3 of Table 6). These can be synthesised as follows:

- Complex and organizational innovation are confirmed to play a very important role as drivers of firms' performances in both macro sectors;
- Somehow unexpectedly, the economic impact of the organizational mode is higher and more significant in the manufacturing industry than in services;
- Pure product and process oriented innovation strategies exert a positive a significant impact on firms' economic performances only in the manufacturing sector.

These findings convey three major (intertwined) messages.

The first is that despite different types of strategies are feasible in both macro sectors, it is the adoption of a more systemic approach to innovation - made of the combination of product, process and organisational change - which gives firms a true competitive advantage.

The second one is that the competitive premium associated to the adoption of a complex innovation strategy is greater in services than in the manufacturing sector. In other words innovation competitive models in the tertiary sector seem to be more binding, requiring the adoption of a more systemic approach to innovation. This also applies to organizational innovation which, as a stand alone type of innovation, produces less economic effects in services than in the manufacturing industry.

The third message is that while in the manufacturing sector innovation activities and strategies conceived and implemented in a strict technological domain find a proper justification and economic rationale, the same does not apply in services. A substantial amount of literature shows that within the manufacturing industry we find both product and process oriented innovation strategies and that these can be both effective depending on the specific context and technological regime in which firms operate. Our results show that this is true (to some extent) only in the manufacturing sector. This type of finding needs however to be combined with the results presented in the previous section which showed the presence and consistency – also in services – of pure product and process innovation modes. What this mixed evidence suggests is that if on the one hand the product/process distinction is effective in discriminating between different (to some extent sector specific) innovation modes in both manufacturing and service industries, in the case of services the same distinction is not effective in discriminating between better and worse economic performances. In other words these results seem to show that, especially in the service sector, the most effective way of getting a competitive advantage is to

deviate from a narrow and technology based approach to innovation adopting more complex strategies.⁵

The results of the estimations carried out on different sub-groups of manufacturing and service industries largely confirm the indications and messages discussed above, with few additional qualifications (see Table 7). More in particular:

- a) The complex innovation mode is confirmed to exert the strongest impact in most of the manufacturing and service sectors taken into account in our analysis. More in particular the strongest and most significant economic impact of this type of innovation strategy is found in the manufacturing Specialized Suppliers industries and in the Transport sectors.
- b) Organizational innovation is confirmed to play a more important role, as a driver of firms' performances in the manufacturing industries than in services. High and significant *b* coefficients are found in all manufacturing industries with the exclusion of the Science based ones, for which a pure organizational approach to innovation is not consistent with high technological profile of these sectors. The strong role played by a pure organizational strategy in Scale intensive and Supplier dominated sectors is a somewhat expected result. As far as services are concerned in two out of the four macro sectors, innovating only through organizational changes is not sufficient to give a competitive premium versus non innovative firms. This is again a somewhat unexpected result.
- c) Pure product and process innovation strategies play a positive impact on firms' performances more frequently in the manufacturing sectors than in services. In the case of manufacturing industries the results are somewhat consistent with what we might have expected taking into the basic characteristics of Pavitt industrial categories, as in the case of the important role played by the process innovation mode in the Supplier dominated and Scale intensive sectors. In the case of Science based industries we do not find any significant association between the four innovation modes and the economic performance indicator and this is a rather puzzling result.⁶

⁵ This double-faced finding might be also connected to the fact that our "innovation modes" were intended to capture both some very basic characteristics of innovation regimes and a behavioural/strategic component of firms innovation activities. It is possible that with the type of data at our disposal we have been more effective in discriminating between different innovation regimes and less effective in discriminating between different firm specific assets and strategies especially in the non-technological domain..

⁶ The non significance of innovation modes in science based industries can be due to several factors the most important being the cross sectional nature of our analysis and the fact that in this group of sectors innovation is a widespread phenomenon. Firms that have not innovated during the three years covered by CIS are likely to be still benefiting from the innovation introduced in the previous period.

(Table 7 around here)

6. Conclusions

The evidence presented in this paper is the result of a rather exploratory exercise aiming at shedding some empirical light on a very complex and under-investigated topic. The main results of this empirical exercise can be synthesised as follows:

- Enlarging the analysis of innovation beyond the technological domain provides a much richer and complex picture of firm's innovation strategies and performances. The traditional distinction (or dichotomy) between product and process innovation is not sufficient to depict the variety of innovation modes, which differentiate firms innovation strategies both within the manufacturing and service sector.
- Four distinct innovation modes have been identified on the basis of the specific type of innovation introduced by manufacturing and service firms and the ways which firms combine technological and non technological innovations: two of these innovation modes are characterized by pure *process* and *product* oriented innovation activities; a third is based on the introduction of pure *organisational* innovations and a fourth one is characterized by a more complex mix of product, process and organisational changes. The descriptive and statistical evidence presented in section 4 has shown that these four different modes of innovation are present and relevant in both manufacturing and service sectors, although the proportion of firms innovating exclusively through organizational changes is somewhat higher in the tertiary sector than in the manufacturing industries.
- The four innovation modes have a different impact on firms' innovation performances. The complex mode is by far the most effective one, giving to firms introducing both technological and organizational innovations a clear competitive advantage with respect to both non innovating firms and firms with a narrow approach to innovation. An interesting finding emerging from our empirical analysis is nonetheless the very important role played by organizational changes (also when not linked to other types of innovation) as a driver of firms' performances.

- As far as the impact of these different types of innovation strategies on firms' performances both similarities and differences between manufacturing and service industries have emerged. The most important similarity has to do with the dominant role played *complex* and *organizational* innovation modes as drivers of firms' performances. Somehow unexpectedly, the economic impact of the organizational mode is higher and more significant in the manufacturing sectors than in services while – and perhaps more important - pure product or process oriented innovation strategies exert a positive a significant impact on firms' economic performances only in the manufacturing sector. All in all, these findings suggest that despite different types of innovation strategies are feasible in both macro sectors, services firms have “less strategic options” vis à vis manufacturing firms, if they want to get an economic return from innovation. In other words, competitive models in the tertiary sector seem to be more binding (as compared to the ones characterizing the manufacturing sector), requiring the adoption of a more systemic approach to innovation.

The empirical evidence presented in this paper should be considered preliminary and influenced by the crude definitions and indicators of organizational innovation adopted by CIS. More conceptual and empirical work will be needed in order to validate, consolidate (or refute) these types of findings. Nonetheless, the empirical exercise proposed provides a general methodological indication in favour of the adoption of a *synthesis approach* to the study of innovation and its economic effects. The adoption of such an approach is quite a challenging venture, since it requires bridging two separate bodies of literature and empirical research, namely those dealing with technological innovation and organisational innovation. The difficulty of this task is increased by the asymmetric state of the art of these two streams of empirical and theoretical investigation. While the concepts, definitions and datasets related to firms' technological activities are fairly established, this is not the case for organisational changes. Future advances in a synthetic perspective will depend crucially on the possibility for advancing and integrating robust and meaningful conceptual frameworks and data, in both domains.

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Figure 1 : A stylised representation of the innovation-performance linkages

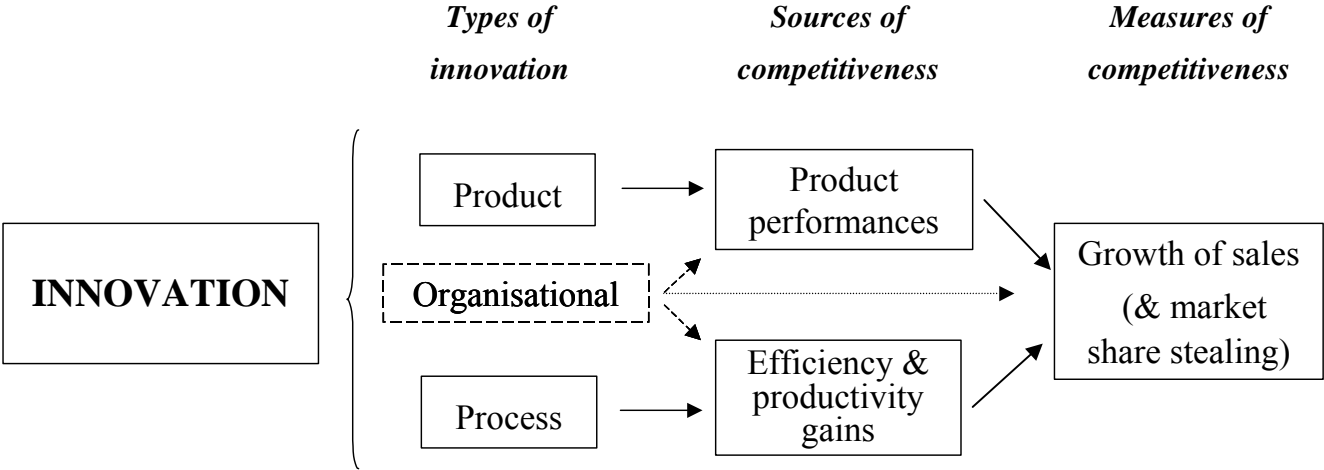


Table 1 - Indicators used in the empirical analysis

Indicators	Label	Description	Used in:
Type of innovation introduced	-	<i>Dichotomics for:</i> only product - only process - product & process - only organisational - only marketing - organisational & marketing	Cluster Analysis
Effects of technological innovation - <i>product oriented</i>	tec_prod	<i>Mean between</i> “Increased range of goods or services”, “Entered new markets or increased market share” and “Improved quality of goods or services”, which are <i>categorical</i> with range 0-3	Probit Regression
Effects of technological innovation - <i>process oriented</i>	tec_proc	<i>Mean between</i> “Improved flexibility of production or service provision”, “Increased capacity of production or service provision”, “Reduced labour costs per unit output” and “Reduced materials and energy per unit output”, which are <i>categorical</i> with range 0-	
Effects of non-tech. innovation - <i>product oriented</i>	nontec_prod	<i>Mean between</i> “Reduced time to respond to customer or supplier needs” and “Improved quality of your goods or services”, both <i>categorical with</i> range 0-3	
Effects of non-tech. innovation - <i>process oriented</i>	nontec_proc	Reduced costs per unit output (<i>categorical</i> , range 0-3)	
Innovation performances	in_turn	% of turnover from innovative goods and services introduced in 2002-04	
	in_exp	Innovation expenditure per employee (2004) - Log	
Process related innovation expenditures	in_mac	expenditures for acquisition of machinery, equipment and software as % total innovation expenditure	
Firm size	19	<i>Dicothomic</i> , 1 if less than 20 employees	Probit & OLS
	20_49	<i>Dicothomic</i> , 1 if between 20 and 49 employees	
	250_more	<i>Dicothomic</i> , 1 if 250 or more employees	OLS
	lemp02	No of employees in 2002 (Log)	
Other firm variables	Group	<i>Dicothomic</i> , 1 firm belongs to a group	Probit
	lturn02	Turnover in 2002 (Log)	OLS
Market characteristics	herfindal	Herfindall Index indicator, measure of the degree of competition among firms (computed at 3-digit level)	OLS
	mkt_size	Market of prevalence: regional, national, international (0-1-2)	
	h_dem	Lack of demand for innovative good or services as obstacle to innovate (<i>categorical</i> , range 0-3)	
Labour productivity	prod02	Turnover/employee ratio (2002)	
Innovation modes	<i>Complex</i>	<i>Dicothomic</i> , 1 for cluster appartenance	
	<i>Process</i>	<i>Dicothomic</i> , 1 for cluster appartenance	
	<i>Product</i>	<i>Dicothomic</i> , 1 for cluster appartenance	
	<i>Organisationa</i>	<i>Dicothomic</i> , 1 for cluster appartenance	

Table 2 - Distribution of firms within clusters according to the type of innovation introduced

Clusters (Innovation)	Type of innovation introduced					
	Technological			Non-technological		
	Only Process	Only Product	Product & Process	Only Marketing	Only Organis.	Organis. & Marketing
<i>Product oriented</i>		<u>63,60%</u>		<u>43,90%</u>		<u>20,30%</u>
<i>Process oriented</i>	<u>65,00%</u>			5,40%		51,80%
<i>Organis. oriented</i>	23,60%	8,50%			<u>100,00%</u>	
<i>Complex</i>			<u>100,00%</u>	6,40%	<u>31,90%</u>	<u>41,30%</u>
All innovative sampl	25,70%	11,30%	25,00%	8,80%	43,20%	26,80%

Table 3 - The profile of Innovation modes (probit estimates) - All sample

	<i>Product</i>	<i>Process</i>	<i>Organisational</i>	<i>Complex</i>
<i>Effects of tech. innovations</i>				
product related (tec_prod)	0,033 (6.91) **	-0,088 (-12.12) **	-	0,065 (7.53) **
process related (tec_proc)	-0,103 (-16.94) **	0,064 (7.26) **	-	0,09 (8.72) **
<i>Effects of non-tech. innovations</i>				
product related (nontec_prod)	-	-0,077 (-6.97) **	0,116 (14.25) **	0,051 (4.10) **
process related (nontec_proc)	-	-0,017 (-1.68)	0,012 (1.72)	0,012 (1.06)
job_sat	-	-0,041 (-3.42) **	0,05 (6.18) **	-0,012 (-0.88)
<i>Innovation expend. and output</i>				
in_turn	0,127 (8.76) **		-	0,665 (22.39) **
in_mac	-0,11 (-8.83) **	0,193 (10.69) **	-	-0,065 (-2.87) **
in_exp	-0,007 (-2.01) *	-0,015 (-3.04) **	-	0,028 (4.64) **
<i>Firm size (No of empl.)</i>				
_19	0,032 (2.76) **	0,049 (2.93) **	-0,015 (-1.1)	-0,072 (-3.66) **
_20_49	0,03 (2.32) *	0,024 (1.26)	0,04 (2.53) *	-0,075 (-3.46) **
_250_more	-0,003 (-0.22)	-0,049 (-2.39) *	-0,087 (-4.97) **	0,114 (4.78) **
Group	0,015 (1.53)	0,005 (0.35)	-0,048 (-3.73) **	-0,03 (-1.69)
Industrial dummies ^a	0.000 **	0.000 **	0.000 **	0.000 **
Observations	5170	5170	8213	5170
Pseudo R-squared	0,15	0,23	0,13	0,22

Notes: Reported are marginal effects at the sample mean, absolute value of z statistics in parentheses.

a: inclusion of 8 industrial dummies computed on the basis of Pavitt, 1984 and Evangelista, 2000, coefficients refer to the p-value of a test of the joint significance of industry fixed effects.

* significant at 5%; ** significant at 1%

Table 4 - Relevance of Innovation modes across industries (% of firms)*

	<i>Process</i>	<i>Product</i>	<i>Organis.</i>	<i>Complex</i>
Manufacturing	32,4	15,8	27,6	24,2
- Science based	16,0	26,7	15,6	41,7
- Scale intensive	36,4	8,2	34,1	21,2
- Specialized suppliers	14,7	24,7	27,5	33,1
- Supply dominated	41,7	17,4	22,4	18,6
Services	30,4	11,8	38,9	19,0
- Trade & Leisure	38,9	13,7	29,9	17,5
- Transport	21,1	9,2	51,9	17,8
- Finance & Banking	18,7	4,9	43,8	32,7
- Business services	17,7	10,7	49,1	22,6

*Figures computed with data reported to the universe using weighting factors

Table 5 - The profile of Innovation modes in Manufacturing and Service industries (probit estimates)

	Manufacturing				Services			
	Product	Process	Organis.	Complex	Product	Process	Organis.	Complex
Effects of tech. innovations								
product related (tec_prod)	0,035 (5.55) **	-0,106 (-10.53) **	-	0,066 (5.54) **	0,03 (4.15) **	-0,068 (-6.39) **	-	0,064 (5.07) **
process related (tec_proc)	-0,106 (-13.57) **	0,069 (5.78) **	-	0,101 (7.25) **	-0,094 (-9.95) **	0,058 (4.47) **	-	0,079 (5.05) **
Effects of non-tech. innovations								
product related (nontec_prod)	-	-0,088 (-5.66) **	0,107 (10.33) **	0,067 (4.06) **	-	-0,061 (-3.89) **	0,12 (9.84) **	0,026 (1.35)
process related (nontec_proc)	-	-0,038 (-2.52)	0,038 (4.23) **	0,016 (1.02)	-	-0,001 (-0.09)	-0,016 (-1.53)	0,009 (0.56)
job_sat	-	-0,02 (-1.14)	0,028 (2.6) **	-0,019 (-1.06)	-	-0,062 (-3.73) **	0,065 (-5.6) **	-0,001 (-0.04)
Innovation expend. and output								
in_turn	0,128 (6.57) **	-	-	0,714 (17.14) **	0,123 (-5.73) **	-	-	0,61 (14.41) **
in_mac	-0,147 (-8.59)	0,252 (10.18) **	-	-0,075 (-2.40) *	-0,064 (-3.5) **	0,119 (4.49) **	-	-0,046 (-1.37)
in_exp	-0,005 (-1)	-0,016 (-2.28) *	-	0,027 (2.93) **	-0,007 (-1.57)	-0,013 (-2.07) *	-	0,028 (3.45) **
Firm size (No of empl.)								
_19	0,039 (2.54) *	0,055 (2.47) *	0,011 (0.63)	-0,101 (-3.86) **	0,026 (1.47)	0,031 (1.23)	-0,039 (-1.85)	-0,038 (-1.27)
_20_49	0,049 (2.77) **	0,007 (0.26)	0,059 (2.95) **	-0,082 (-2.80) **	0,008 (0.39)	0,04 (1.43)	0,02 (0.85)	-0,07 (-2.15) *
_250_more	-0,002 (-0.11)	-0,05 (-1.78)	-0,098 (-4.47) **	0,156 (4.81) **	-0,008 (-0.37)	-0,044 (-1.47)	-0,077 (-2.87) **	0,07 (1.97) *
Group	0,013 (0.96)	0,008 (0.38)	-0,013 (-0.77)	-0,05 (-1.98) *	0,022 (1.46)	-0,002 (-0.08)	-0,073 (-3.93) **	-0,015 (-0.58)
Industrial dummies ^a	0.839	0.000 **	0.025 *	0.000 **	0,008 **	0.000 **	0.000 **	0,418
Observations	2963	2963	4275	2963	2207	2207	3938	2207
Pseudo R-squared	0,19	0,28	0,14	0,24	0,11	0,18	0,08	0,2

Notes: Reported are marginal effects at the sample mean, absolute value of z statistics in parentheses.

a: inclusion of 8 industrial dummies computed on the basis of Pavitt, 1984 and Evangelista, 2000,

coefficients refer to the p-value of a test of the joint significance of industry fixed effects.

* significant at 5%; ** significant at 1%

Table 6 - The impact of innovation on firms competitiveness - OLS estimates

	All sample	Manufacturing	Services
<i>Product</i>	2.110 (0.837) *	2.277 (1.071) *	2.114 (1.358)
<i>Process</i>	2.437 (0.619) **	3.427 (0.835) **	1.097 (0.924)
<i>Organisational</i>	3.633 (0.576) **	4.591 (0.859) **	2.728 (0.776) **
<i>Complex</i>	5.389 (0.672) **	5.771 (0.892) **	5.216 (1.034) **
herfindal	16.269 (2.675) **	12.220 (3.806) **	20.914 (3.766) **
prod02	-0.009 (0.001) **	-0.006 (0.002) **	-0.010 (0.001) **
lemp02	-0.866 (0.178) **	-1.387 (0.257) **	-0.309 (0.248)
mkt_size	0.692 (0.376)	-0.012 (0.555)	1.414 (0.510) **
h_dem	-1.003 (0.186) **	-1.294 (0.261) **	-0.662 (0.265) *
Industrial dummies ^a	0.000 **	0.000 **	0.000 **
Constant	21.082 (3.003) **	24.973 (2.734) **	11.352 (3.046) **
Observations	13870	7054	6816
Prob > F	0.000	0.000	0.000
R-squared	0.05	0.06	0.05

Notes: Standard errors in parentheses. a: inclusion of industrial dummies computed at a 2-digit level, coefficients refer to the p-value of a test of joint significance.

* significant at 5%; ** significant at 1%

Table 7 - The impact of innovation on firms competitiveness - OLS industry estimates

	Manufacturing				Services			
	Science based	Scale intensive	Specialized suppliers	Supply dominated	Trade & Leisure	Transport	Bank & Finance	Business Services
<i>Product</i>	5.072 (2.846)	4.354 (2.002) *	-0.971 (2.808)	1.551 (1.702)	0.489 (1.676)	12.774 (3.878) **	-0.519 (3.879)	0.941 (3.382)
<i>Process</i>	5.202 (3.310)	2.557 (1.283) *	5.151 (3.112)	3.803 (1.237) **	1.043 (1.122)	-1.684 (2.548)	0.718 (2.461)	2.185 (2.594)
<i>Organisational</i>	0.246 (3.170)	5.157 (1.269) **	8.813 (2.397) **	2.883 (1.433) *	2.520 (1.109) *	2.332 (1.851)	0.579 (1.961)	3.760 (1.784) *
<i>Complex</i>	4.334 (2.491)	5.548 (1.449) **	8.360 (2.342) **	5.802 (1.594) **	4.227 (1.605) **	8.244 (2.948) **	2.485 (2.249)	7.395 (2.207) **
herfindal	-18.218 (11.233)	11.267 (6.452)	18.001 (11.442)	17.525 (5.870) **	40.650 (6.264) **	7.138 (6.278)	-30.539 (24.167)	25.452 (8.723) **
prod02	-0.017 (0.005) **	-0.002 (0.004)	-0.022 (0.007) **	-0.002 (0.003)	-0.010 (0.002) **	-0.009 (0.004) *	-0.007 (0.003) *	-0.019 (0.005) **
lemp02	-1.814 (0.769) *	-0.819 (0.436)	-1.573 (0.639) *	-1.848 (0.428) **	1.077 (0.365) **	-1.149 (0.571) *	-1.244 (0.604) *	-0.792 (0.603)
mkt_size	1.862 (2.104)	-0.088 (0.854)	0.774 (1.609)	-0.563 (0.885)	0.181 (0.653)	3.250 (1.233) **	2.829 (1.436) *	2.256 (1.449)
h_dem	-1.135 (0.901)	-0.373 (0.413)	-1.987 (0.764) **	-1.996 (0.410) **	-0.972 (0.351) **	-0.436 (0.641)	1.338 (0.735)	-1.034 (0.639)
Constant	17.928 (5.296) **	14.595 (3.422) **	11.297 (5.939)	27.391 (3.007) **	5.142 (1.760) **	13.534 (4.753) **	13.046 (4.665) **	10.831 (4.339) *
Industrial dummies ^a	0.229	0.000 **	0.354	0.000 **	0.000 **	0.792	0.000 **	0.000 **
Observations	704	2649	1012	2689	3205	1215	840	1556
Prob > F	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R-squared	0.04	0.03	0.04	0.11	0.05	0.03	0.05	0.04

Notes: Standard errors in parentheses. a: inclusion of industrial dummies computed at a 2-digit level, coefficients refer to the p-value of a test of joint significance.

* significant at 5%; ** significant at 1%