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The role of design in firms' innovation activity: A micro level analysis[1]

Working Paper

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Abstract

The empirical literature investigating the issue of the heterogeneity across firms has proposed the concept of *innovation modes*. This aims at grouping firms depending on a number of innovation characteristics. The role of design as a source of innovation has been largely disregarded. The aim of this paper is to fill this gap as it *i.* seeks to identify the main characteristics of firms which rely on design for their innovations; *ii.* aims to bring the role of design within the framework provided by the literature on the innovation modes of firms. Design activity is predominant in firms characterized by: *i.* complex innovation strategy, and *ii.* intense interaction with the external environment. Investment in design it is associated with higher performance of the firm.

[1] This research has been developed during my visiting period at Birkbeck College – University of London thanks to a DIME mobility fellowship. I wish to thanks Marion Frenz for very helpful comments, and Birgitte Andersen as DIME coordinator at Birkbeck. Finally, I would like to thanks Keith Sequeira and the DG Enterprises and Industry of the European Commission for allowing me to use the data of the Innobarometer Survey.

Innovation within the firm has nothing to do with R&D activities.
Steve Jobs (Kahney, 2008)

1. **Introduction**

Over the last decade the literature investigating patterns of innovation has devoted increasing attention to empirical analysis at the micro level, as the relevance of the heterogeneity across firms with regard to innovation behaviour has been increasingly recognized (OECD, 2009). A stream of empirical studies (reviewed in the second section) has tackled the issue of the heterogeneity across firms by putting forward the concept of *innovation modes*. This is grounded on the awareness that firm-specific factors play a fundamental part in shaping a complex phenomenon such as innovation. Accordingly, the presence and the source of regularities – patterns – in the innovative behaviour should also be investigated at the micro level. The innovation modes research presented here, empirical in nature, aims at grouping firms depending on a number of characteristics of innovation. They include, together with structural characteristics of the firm, several innovative dimensions such as the formal R&D activities, collaboration activities, the role of investment in ICT and capital, knowledge management and organizational innovation, as well as marketing and service innovation.

In this stream of studies R&D activity is regarded as the major internal source of knowledge generation and learning, as well as a fundamental source of firms' competitiveness. But in more recent years, increasing attention has been devoted to the role played by non-technological innovation such as innovation in services (Evangelista, 2000; Mansurya and Love, 2008; Gallouj and Djellal, 2010), organizational innovation (Armbruster et al., 2008; Tether and Tajar, 2008), as well as fixed capital investment (Evangelista, 1999). These studies have further enlarged our understanding in innovation, but the role of design has thus far received little attention . However, previous studies show that design activity represents an important internal source of knowledge generation and learning, with its own organizational structure and processes, deep interactions with other functions of the firms, as well as external linkages (Verona and Ravasi, 2003; von Stamm, 2003; Filippetti, 2010). In addition, there is a growing body of evidence showing the positive impact of design on different dimensions of company performance,[2] as well as the central contribution design activity makes to innovation (Walsh, 1996; von Stamm, 2004; Candi and Saemundsson, 2008; Verganti, 2008). Finally, design is increasingly playing a role in relation to innovation in the service sector (Garrone and Colombo, 1999; Ma et al., 2002). Overall, this research calls for a greater attention which should be devoted to the role of design within the innovative activity of firms.

Thus, there is a considerable gap between innovation studies addressing patterns of innovation and the heterogeneity at the micro level, on the one hand. And a growing evidence supporting the prominence of design activity, in enhancing innovation capabilities and the competitiveness of the firm, on the other hand. This paper aims to fill this gap in the literature, trough a micro-level analysis on more than 5,000 firms, as it *i.* seeks to identify the main characteristics of firms which rely on design in relation to their innovative activities, by generalizing the main findings of previous case study research; *ii.* aims to bring design within the framework provided by the literature on the innovation modes of firms.

A fundamental tool to tackle the heterogeneity of innovative activities has been the increasing availability of data at the firm level. The major role has been played by the Community

[2] See Lorenz, 1986; Walsh et al., 1992; Roy and Potter, 1997; Roy and Riedel, 1997; Gemser and Leenders, 2001; Cereda et al., 2005; Hertenstein et al., 2005; Tien et al., 2005; Marsili and Salter, 2006; Chiva and Alegre, 2007; Piirainen, 2007; Czarnitzki and Thorwarth, 2009.

Innovation Survey (CIS) (Archibugi and Pianta, 1996; Smith, 2005). Over the last few years a second survey managed by the European Commission, namely the *Innobarometer Survey*, has been developed and carried out across Europe. In this paper the last Innobarometer (European Commission, 2009b) carried out on April 2009 covering 5,234 firms is used.
The paper is organized as follows. The next section provides the theoretical framework by reviewing the literature on innovation modes of firms. Section three seeks to generalise the findings of previous case study research regarding the characteristics of firms devoted to design activity. Section four aims to bring design into the picture of innovation modes through an explorative analysis of firms' innovation activities. Section five investigates the dynamic of the economic performance across the identified innovation modes. Finally, section six discusses the main results and some policy conclusions.

2. Patterns of innovation activities across heterogeneity of firms: a review of the 'innovation modes' literature

A great deal of literature has been focusing on the importance of industry-specific factors to explain patterns of innovation of firms and the dynamic of the industrial structure (Pavitt, 1984; Archibugi et al., 1991; Malerba and Orsenigo, 1994; Freeman and Soete, 1997; Breschi et al., 2000; Archibugi, 2001; Malerba, 2004). The main assumption lying behind these studies is that patterns of innovation of firms are sector-specific, depending on the very nature of the technological domain. Even though this body of literature has provided important insights about the way firms innovate, further analysis shows that sectors matter to a certain extent, but heterogeneity among firms plays a crucial role *within* both sectors and countries (Srholec and Verspagen, 2008).

Within this perspective, over the last decade, a growing empirical literature has been focusing on the sources of heterogeneity at the firm level. Different dimensions of heterogeneity have been investigated, including the typology of innovation (e.g. product, process, service), the sources of innovation and the related strategies (i.e. in-house vis-à-vis outsource R&D), and the growing importance of non-technological innovation. This has led to the concept of *innovation modes,* aiming at grouping firms depending on a number of characteristics of the innovation activities, behaviours and strategies. In what follows, the main studies and empirical evidence of this literature are briefly reviewed.

Laursen and Foss (2003) explore the complementarities between new human resource management practices and their impact on innovation performances using data from a Danish survey of 1,900 business firms. They identify two main practices across firms and they find that the adoption of a package of these practices significantly affects innovation performance of firms. On a similar note, Arundel et al. (2007) compare the work organization environment and innovation patterns at the country level. Building on firm level data – the Third European Survey of Working Conditions and the third CIS (CIS-3) – they put forward a taxonomy of four different modes of organization of work and three innovation modes, i.e. *Lead innovators, Technology modifiers,* and *Technology adopters.* They find significant differences across countries (even after controlling for industrial structure) in the way work is organized and how firms innovate.

The identification of innovation modes in the service sector is also the aim of an empirical paper by Hollenstein (2003) based on a survey including 2,731 Swiss firms. Based on different groups of variables – innovation typologies, sources of innovation and investments – the author identifies five different innovation modes. He concludes that innovations in

services differ from those in manufacturing in terms of lower levels of R&D and the major role played by non-technological factors in some segments of the service sector.

Jensen et al. (2007) emphasize how different strategies of knowledge creation and learning processes are relevant sources of firms' heterogeneity which are related to their innovation behaviours. They propose two different innovation modes, one based on the production and use of codified scientific and technical knowledge, and the other relying on informal processes of learning and experience-based know how. Using a Danish dataset including 700 firms they show that firms which adopt strong versions of both practices tend to improve their innovative performance. Additionally, they find evidence that mixed strategies tend to perform significantly better than those relying solely on one or the other of the two modes.

Tether and Tajar (2008) use the Innobarometer survey carried out in 2002 to investigate the importance of organizational innovation. Their major finding is that, together with well-established patterns of innovation based on product innovation and process innovation, a third relevant "organizational-cooperation mode of innovation" emerges. This mode of innovation results particularly relevant amongst service sector firms. Evangelista and Vezzani (2008) explore the relationships between technological and non-technological innovation modes (and a combination of the two) and the effects on economic performance and employment using Italian CIS-4 data.

Srholec and Verspagen (2008) assess the heterogeneity of the innovation processes using exploratory factor analysis on micro data from the CIS-3 across thirteen countries. Their analysis shows that while sectors and countries matter to a certain extent, the larger share of variance in terms of innovation strategies, has to be related to the heterogeneity within both sectors and countries. Finally, in a recent study based on the UK data, Frenz and Lambert (2009) using micro-level innovation survey data concerning innovation find that productivity measured by value added per capita is influenced more strongly by non-technological innovation modes, whereas output per capita is relatively more strongly and significantly related to product, process and technology based innovation.

All the studies discussed above share the same theoretical underpinning and a similar methodological approach. The former is the need to take into account the heterogeneity that characterizes firms' behaviours in relation to innovation activities, dimensions and strategies. From a methodological standpoint, they all address heterogeneity in firms' innovation activities relying on explorative multivariate analysis such as factor analysis and cluster analysis. In these studies the role of non-technological forms of innovation, such as organizational innovation, human resources management practices, innovation in services has been increasingly addressed.

However, the role played by design innovation is still underexplored.[3] When included in the analysis it is associated with marketing innovation and is not specifically addressed (Srholec and Verspagen, 2008). This can be explained by two main reasons. First, although some scholars have recognized the important role of design concerning innovative activities (Walsh, 1996) it has not been taken into full account in the economics of innovation literature yet. In this literature R&D is regarded as the major source of knowledge generation. Accordingly, a lot of attention is devoted to R&D activity, in terms of internal processes, external sources and complementarities (see for example, Cassiman and Veugelers, 2006). This is also well reflected in innovation policy which is still strongly R&D-centric.

[3] For some first attempts to investigate design at the micro-level see Cereda et al. 2005; Marsili and Salter, 2006.

The second (and related) reason is the lack of data. In the harmonized CIS-4 questionnaire the role of design is explicitly considered as a marketing innovation: "a marketing innovation is the implementation of new and significantly improved design and sales methods to increase the appeal of your goods and services or to enter to new markets". This derives from the last edition of the Oslo Manual in which one can find that *"marketing innovations involve the implementation of new marketing methods. These can include changes in product design and packaging, in product promotion and placement, and in methods for pricing goods and services"* (OECD, 2005, p. 17).

3. The characteristics of design-based companies: an attempt to generalize previous findings of case study research

As already maintained in the introduction, there is now a great deal of evidence showing the importance of design in relation to innovation and the competitiveness of the firm. As a matter of fact, most of this research has been so far based on case study research. This section seeks to generalise the findings of a previous case study research regarding the characteristics of design-based companies (Filippetti, 2010).[4]

The research has been based on a multiple case study carried out in Italy in 2009. Twenty direct interviews with designer consultants and firms that are leaders in design across several industries were carried out. The study focused in particular on *product design.* We found that in order to carry out design innovation, firms need to deal with several factors, such as scientific and technical advancements (materials, production techniques, technologies), industry dynamics, as well as the evolution of the demand and social aspects. Additionally, even when design is carried out by external designer consultants, they closely interact with the firm's functions, such as the R&D lab, as well as the production and marketing department. In the following the main results are summarized in five propositions to be tested in this paper's analysis.

3.1. The main results of the case study and five propositions to be tested

Design activity is closely intertwined with technological development, new materials and production techniques. Consequently, designers, both internal and external, develop a close relationship with, and deep understanding of, the production capabilities of the firm, and the R&D department. Hence, I derive the following proposition:

Prop. 1. Firms that carry out innovation design are also technology-intensive.

I have already mentioned the importance of the production process of the firm in relation to the design activity. It arises that design makes a fundamental contribution not only concerning new products, but also in relation to the production process in terms of: *i.* new materials; *ii.* new production techniques; *iii.* introduction of process innovation themselves. Accordingly, the following proposition is:

Prop. 2. Firms that are active in design are also involved in process innovation.

While in some cases the importance of universities and research centres emerged, the crucial role of the interaction with *suppliers* in providing new materials, production processes and technologies emerged as a key characteristic of firms involved in design activities. Consequently, proposition 3 suggests that:

[4] In line with these results see also Utterback et al., 2006 and Verganti, 2008 among others.

Prop. 3. Firms that carry out innovation design rely on out-of-the boundaries collaboration – interactions - in particular with specialized suppliers and to a lesser extent with universities.

Concerning the methods of appropriating returns from innovative activities, the findings are similar to those already highlighted by the literature related to technological innovation and patents (see for example Cohen et al., 2000). Firms are inclined to use design registrations – intellectual property rights (IPRs) - even if they are well aware of their limitations in providing an effective protection. Therefore, the following proposition is put forward:

Prop. 4. Firms rely (also) on IPRs to protect the outcomes of their design innovation activity.

Finally, large firms seem more likely to invest in design, and therefore the last preposition to be tested is the following:

Prop. 5. Innovation design is more likely to occur in large firms.

3.2. The data: the Innobarometer 2009 Survey

The data derives from the *Innobarometer Survey 2009* designed and collected by the European Commission (European Commission, 2009). Innobarometer is conducted on a yearly basis since 2001. The current Innobarometer was conducted during April 2009 in the 27 Member States of the EU, Norway and Switzerland. The current wave of Innobarometer (2009) placed the focus on innovation, and the reference period of the various activities surveyed was that between 2006 and 2008. The targeted number of main interviews varied somewhat in accordance to the size of the respective country; however, the default sample size was 200 in most EU Member States. In total 5,238 enterprises from the 27 EU Member States, plus Norway and Switzerland responded to the questionnaire. The sample is a random one stratified by country, enterprise size (5 size bands) and industry (2-digit) (Table A1 in the Appendix). The Innobarometer reports further details on the survey procedure (European Commission, 2009b).

The Innobarometer has been already used for this kind of research (see for example, Tether and Tajar, 2008). While the most used dataset has been the CIS. The latter includes a larger number of firms and also allows for dynamic investigation. However, the Innobarometer has a fundamental advantage when compared with the CIS in relation to this paper's topic, as it includes a specific question about design as a *source of innovation*. Importantly, the question about design is included in the same question related to the other innovation inputs, such as R&D (both in-house and external) and acquisition of external know-how and machineries. This is not negligible when we compare it with the CIS, where design is explicitly considered as a marketing innovation, and therefore an output. I will show that the results about the characteristics of the innovation modes are in tune with prior evidence. This supports the case for the use of this dataset, as allows to better address the role of design.

A central issue in research dealing with design is that design is a multifaceted and broad concept with no commonly agreed definition. As Walsh claims "the term 'design' covers a wide range of activities: architecture, fashion design, interior design, graphic design, industrial design, engineering design" (Walsh, 1996, p. 512). In what follows, she also points out that engineering design has evolved into a separate discipline from industrial design. The question related to design included in the Innobarometer Survey refers to a broad definition of design activity, as it encompasses graphic, packaging, process, product, service or industrial

design. Importantly engineering design is not included.[5] This wide definition is therefore suitable for an explorative approach as the one carried out in this paper.

3.3. The results

In Table 1 the number of firms grouped by innovation inputs and innovation typologies is reported. Among the innovative firms, 43 per cent, reported they rely on design as an input for innovative activities. When compared to other inputs and other non-technological forms of innovation activities, namely marketing and organizational innovation, it emerges that the role of design is not negligible. It is, at least possible to claim that there is no evident reason not to take it into account with respect to the other technological and non-technological forms of innovation.

---[Table 1]---

In Table 2, the results of a "robust" logit regressions are reported. They estimate the impact of some of the characteristics of the firm on the probability of carrying out design as an input of innovation activity. The dependent variable is a categorical variable (yes or no type) which identifies firms which have expenditures in design in relation to innovation activity. Independent variables are also categorical variable (yes or no type) and refer to *(i).* typologies of innovation (product, service, process); *(ii).* sources of knowledge (internal R&D, external R&D); and, *(iii).* collaboration activities (involving customers, suppliers, universities or other firms). The model also includes the complete set of sectoral and country dummies, as well as control variables controlling for turnover performance and intensity of innovation expenditures (see Table 3 for a description of the variables). In the following, the results are discussed with respect to the prepositions put forward.

First, the result about the role of R&D lends support to the argument that design is linked to technological development within the innovative activities of firms (preposition no. 1). In addition, the fact that R&D performed in house is largely more important than external R&D suggests a proximity of design to the internal creation of technological innovation rather than to its external adoption. With regard to the second preposition, the role of process innovation (besides product innovation) emerges as a good predictor of design activities. The role of process innovation confirms the fact that design activities act as an important driver to explore new solutions in the production processes of firms, such as new production techniques and processes. I also expected design-based firms to be more likely to establish collaboration activities with suppliers, and to a lesser extent with universities, with regards to their innovative activities. The results suggest that design-based firms are more likely to engage in collaboration with suppliers, while collaboration with universities does not arise as significant. The fact that the role of suppliers is so relevant in comparison to the other is remarkable. In fact, usually firms which cooperate in their innovation activities are inclined to exploit all the external sources at the same time (Laursen and Salter, 2004). Concerning the use of IPRs to protect the outcomes of their innovative activities (proposition no. 4), design-based firms are heavily relying on both patents and design registrations. Unfortunately it is not possible to distinguish among patents and design registrations, thus it is not possible to draw an unequivocal conclusion. With regards to the size issue (proposition no. 5), the proposition results confirmed. While medium size does not result to be significant, the positive coefficient of large firms suggests that large size firms are more likely to carry out design activities, in comparison to small firms.

[5] Engineering design has in fact an important overlap with R&D activities, see, OECD, 2002.

---[Table 2]---

To sum up, this section attempted to provide some degree of generalization to five propositions derived from the findings of previous case study research. The results support the main findings. Specifically, firms which rely on design as innovation input are also devoted to technological innovation through R&D activities with a specific focus on process innovation (other than product innovation). In addition, in these firms collaboration with suppliers emerged as a key characteristic. So far, I have identified the main characteristics of firms involved in design innovation. In what follows, using the same dataset, it is investigated how design comes into the broader picture of the innovation modes when several characteristics of the firm are taken into account, with the aim to identify those modes or strategies of firms that evolve around design. This is followed by a final empirical section that compares the relative importance of the innovation modes, including design based modes, on firm performance.

4. The prominence of design innovation within the innovation modes of the firms

As I showed above the number of firms which rely on design as an internal source of knowledge in relation to innovation activities results relevant when compared to other sources (Table 1). The aim of this section is to bring design into the main picture of the innovation modes. For this purpose it is followed an explorative analysis. A factor analysis, which is commonly used for exploratory, inductive research is carried out first. Second, a cluster analysis based on identified factors is performed in order to ensure a significant number of homogeneous groups of firms.

4.1. The variables

In Table 3 the variables feeding into the explorative analysis are presented. All the variables are categorical dichotomies variables (yes or no type of answers) and they are divided into the following five groups:

Sources of innovation. Among the different sources of innovation it is possible to identify R&D performed in-house and design activity. It is also possible to distinguish among three external sources of innovation, that is external R&D, the acquisition of knowledge (i.e. patents, inventions, know-how) and the acquisition of capital (i.e machinery, equipment and software).

Collaboration activities. Among the different sources of external collaboration it is possible to distinguish between collaboration with customers, suppliers and other firms, in contrast to collaboration with universities and research centres.

Non-technological innovation. Two different forms of non-technological innovation are included, namely, organizational innovation and marketing innovation. At this stage, product, process and service innovation are not included for two main reasons. First, their importance has been already addressed in section three. Second, there is a great overlap between the three innovation outputs as most innovative firms reported product, service and process as innovation outputs. However, their relevance as well as the main differences among the manufacturing and service sectors are addressed in the following.

Activities and methods in support of innovative activities. Methods in support of innovative activities are also included. Specifically, the use of patent and design registration in order to capture whether or not firms follow an appropriability strategy linked to the IPRs. The

adoption of knowledge management practices, as discussed in the literature (Jensen et al., 2007) is also addressed. Finally, a set of questions related to the so-called open innovation paradigm (Chesbrough, 2003) are included. Open innovation practices have hardly ever been addressed in this stream of literature. In this way, this analysis is able to provide a contribution to this emerging issue.

Innovation drivers. Finally, some factors which can drive the innovation strategies of firms are also included. On the one hand, firms' innovative efforts can be driven by cost-reducing reasons and are usually linked to process innovations (Hollenstein, 2003). While on the other hand, firms can be more attracted to exploiting new technological opportunities (Klevorick et al., 1995) and new markets through their innovative activities.

---[Table 3]---

4.2. Explorative analysis

In this section the variables discussed above are used to carry out a factor analysis (see Table A2 in the appendix for descriptive statistics). In line with the previous empirical studies using categorical variables (see for example Frenz and Lambert, 2009), a principal component analysis is carried out based on the tetrachoric correlation matrix between the variables. Table 4 and Table 5 show the results of the factors analysis of the innovation variables (as in Table 3) respectively in terms of explained variance and in terms of factor loadings. The four factors extracted account for 55% of the total variance, with the first two factors accounting for approximately the same amount of variance, around 18% (see Figure A1 in the Appendix for the plot of eigenvalues after the factor analysis).

The factors seem well to reflect some of the most relevant dimensions of the innovation activities of the firms. In particular they can be summarized as follows:

1. factor no. 1 - *technological creation and adoption*: it reflects the importance attached to knowledge, both developed inside the firms and absorbed out of the firms' boundaries. These activities include design as an input and a strong appropriation strategy through the use of patents and design registrations;
2. factor no. 2 – *interacting and searching out of the firm's boundaries:* this factor reflects the attitude of firms to interact and explore new opportunities outside their boundaries. Specifically, by collaborating with suppliers, customers and universities, by implementing open innovation practices, and exploring new technological and market opportunities;
3. factor no. 3 – *non-technological innovation:* this factor accounts for the importance attached to non-technological forms of innovation and specifically to organizational innovation and marketing innovation, as well as knowledge management practices;
4. factor no. 4 – *cost saving strategy:* finally, the last factor accounts for the relevance of cost-saving strategies of innovation activities.

---[Table 4]---

---[Table 5]---

4.3 Identified innovation modes

In this section, the innovation modes identified on the basis of the results of a non-hierarchical cluster analysis are presented. Different solutions from different cluster methodologies have

been compared, also considering different numbers of clusters. The results are quite robust across the different methodologies. The five clusters and the methodology have been chosen trying to balance three different criteria: *i.* statistical significance; *ii.* economic interpretation; and *iii.* a sufficient number of observations within each cluster. Following these criteria five groups have been chosen together with the k-means methodology. The number of observations ranges from 488 of the third cluster to 732 of the first cluster (Table 6). In Table 7 the distribution of the variables within the five identified clusters is reported. On the basis of these results the following five innovation modes have been identified:

Mode 1: "outward-oriented non-technological innovation".

This group of firms consists of 732 firms (24% of the sample) and it is characterized by an intense non-technological innovation activity, namely organizational innovation, marketing innovation and knowledge management practices. The other distinctive feature of this group is the importance attached to collaboration activities mainly with customers, suppliers and other firms in the same field. This group of firms also adopts open innovation practices extensively and is oriented towards the exploration of new technological and market opportunities. Regarding typologies of innovation, process innovation and service innovation are more relevant (Table 8). Concerning size distribution, small firms are more important than large ones (Table 9), while in terms of sectoral distribution the less knowledge-intensive sector is overrepresented (Table 10).

Mode 2: "cost-saving innovation".

Similarly to previous empirical findings (Hollenstein, 2003) one cluster is mainly characterized by the relevance of cost-competiveness innovation together with the importance of the acquisition of external machineries.[6] It accounts for 21% of the sample equal to 655 firms. In this cluster, large firms are underrepresented while small firms are above the average (Table 9). By looking at Table 10 it clearly emerges that cost-saving strategies are more likely to be pursued in the manufacturing sector with respect to services, and specifically in the medium-low tech sector.

Mode 3: "R&D-focus with strong basic collaboration".

This cluster of firms is the smallest, accounting for 488 firms equal to 16% of the sample. Firms here present a strong technological focus of their innovative activities based on R&D, both in-house and external. They present a very low propensity to acquire know-how and machineries from outside. They also show strong linkages with universities and research centres, as well as a propensity to undertake open innovation practices. The size distribution does not significantly differ from that of the sample, while the knowledge-intensive sector plays an important role here with respect to the others (Tables 9 and 10).

Mode 4: "inner-oriented non-technological innovation".

This group of firms resembles the first one in terms of the importance attached to non-technological forms of innovation, specifically organizational innovation and marketing innovation. The major difference lies in the very low propensity to undertake collaboration activities outside their boundaries. In addition, these firms are also less likely to explore technological opportunities and new market opportunities. Similar to mode no. 1, in this cluster process innovation and service innovation are more important that product innovation. In terms of size distribution, small firms are clearly overrepresented with respect to the large ones (Table 9). In relation to the sectoral distribution, the relevance of the service firms and in particular of the "Wholesale, retail and trade" industry emerges.

Mode 5: "outward-oriented multifaceted innovation".

This group accounts for 17 per cent of the sample equal to 534 firms. These firms are primarily characterized by a 360 degrees innovation activity. Non-technological innovation is coupled with R&D activity as well as design activity. They are very active in absorbing

[6] It should be noticed that the acquisition of external machineries is an important feature across all clusters, with the only exception of cluster no. 3.

knowledge and technology from outside in terms of acquisition of know-how and machinery. There are very inclined to establishing out-of-the-boundaries collaboration, especially collaboration with suppliers as well as with universities and research centres. They are also likely to be involved in open innovation practices and exploring new technological opportunities and new markets. This is also the only cluster in which appropriability strategy plays an important role. In this mode, the prominence of product and process innovation with respect to service innovation emerges (Table 8). In terms of firm size, in this cluster large firms play a big role: 43 per cent are large firms with respect to a 28 per cent of the sample, while only 25 per cent of firms are small firms with respect to 38 per cent of the sample (Table 9). Also, the overrepresentation of the high-tech manufacturing sector, in particular the "chemicals" sector, "Machinery and equipment" is evident. Also the knowledge-intensive service innovation is overrepresented with respect to the sample, namely the "Post and telecoms, fin. int., insurance" sector, the "Computer and related activities, R&D" sector and the "Other business activities" sector (Table 10).

---[Table 6]---

---[Table 7]---

---[Table 8]---

---[Table 9]---

---[Table 10]---

To sum up, thanks to the large number of firms it has been possible to delve into some aspects of the heterogeneity of the innovation modes already highlighted by the literature. Two different innovation modes based on non-technological innovation have been identified (mode no. 1 and mode no. 4). In a recent paper already discussed Tether and Tajar (2008) stress the importance of the organizational-cooperation mode of innovation. In line with their results, here both non-technological modes are more relevant in relation to the service sector (see also Hollenstein, 2003). However, the two modes here identified differ in terms of their attitude towards their external environment. That is, cluster no. 1 firms attach a large importance to external collaboration when compared to firms belonging to cluster no. 4. This difference in their relationship with their environment is also reflected in the different propensity of firms in adopting open innovation practices, and about the importance of exploring new technological opportunities and new market opportunities.

A "pure" R&D-based mode of innovation also emerges as relevant. These firms are not very likely to couple R&D activity with non-technological innovation, as well as not tending to acquire knowledge from outside. Consistently with their focus on technology, they are more likely to establish science-based forms of collaboration outside their boundaries. It is worth noting that the knowledge-intensive sector plays an important role.

Finally, a group of firms extremely active in every typology of innovation and involved in every form of collaboration also emerged (cluster no. 5). These firms also show a high propensity to both rely on IPRs as a means of capturing returns from the outcomes of their innovative activities and to adopt open innovation practices. The fact that these firms pursue open innovation practices which include the sharing of knowledge and intellectual property rights is not at odds with the importance they attach to the appropriability strategy. On the contrary, this suggests that an important element of the open innovation strategy is about

balancing the pursuit of proprietary knowledge with some form of open access and sharing of knowledge outside the boundaries of firms.

As far as the importance of design among the identified clusters is concerned, its strong association with mode no. 5 is clear. Design innovation is predominant in a cluster characterized by the presence of large firms with a complex approach to innovation activities and an explorative and interactive attitude out of their boundaries. However, it is also partially present in both the innovation modes characterized mainly by the role of non-technological innovation, an overrepresentation of the service sector as well as a predominance of process innovation (mode no. 1 and mode no. 4). Whilst it is less important in the pure R&D innovation mode. Next section investigates whether there are significant differences across the five innovation modes in terms of economic performance.

5. Innovation modes and economic performance of firms

The relationship between patterns of innovation and economic performance of firms has been one of the line of research addressed by this literature (see for example Cainelli et al., 2006; Jensen et al., 2007; Frenz and Lambert, 2009). This section explores the relationship between the identified innovation modes and the economic performance of firms.

The results of a "robust" ordered logistic estimate are shown in Table 11. The dependent variable is the dynamic of the turnover over the period 2006-2008 and can assume four values (=1 if the turnover decreased; =2 if the turnover increased by less than 10 per cent; =3 if the turnover increased by 10 to 50 per cent; =4 if turnover increased more then 50 per cent). The independent variables of Model 1 are binary variables indicating whether or not the firm belongs to a particular cluster. In Model 2, three sets of control variables are included in order to control for the size of the firms, the intensity of innovation expenditures, and the industry effect.

Model 1 shows that the only two innovation modes which are significant and positive predictors for turnover's growth are the *"outward non-tech"* mode and the *"multifaceted-innovation"* mode.[7] Specifically, firms belonging to the "*multi-faceted innovation*" mode are more likely to show faster rates of turnover's growth with respect to those feeding into the *"outward non-tech"* mode and the others.

---[Table 11]---

When three sets of control variables are added in Model 2, namely firm size, intensity of innovation expenditure and macro-sectoral dummies, the odds ratio relative to the two innovation modes are still positive and significant. Additionally, the difference between the odds ratio relative to the two innovation modes moderately increases. The fact that, in Model 2, the odds ratio of the two modes does not change significantly is worth discussing. As a matter of fact, both firm size, innovation intensity and sectoral dummies are significant and positive. That is, medium and larger firms are more likely to be associated with faster growth

[7] In this section the usual caveat regarding causality when dealing with cross-section analysis applies. As already pointed out in the discussion in the literature review, the relationship between economic performance and innovation activity is very likely to resemble a self-reinforcing mechanism taking place over time rather then showing a one-way direction of causality (see for example Cainelli et al., 2006). However, the main point here is to underline the presence of a significant association between the two phenomena and the differences across the independent variables (innovation inputs and innovation modes).

rates of turnover with respect to small firms. Firms which invest a large share of their turnover (mode than 50 per cent) are also more likely to experience faster turnover's growth. Finally, firms belonging to the high and medium-tech sector and knowledge-intensive sector are also associated to faster rates of turnover. So far this is hardly surprising. However, what is meaningful is that the estimated odds ratio is robust to the introduction of these control variables. And this is particularly remarkable in the case of the *multi-faceted innovation* mode, which is characterized by both an overrepresentation of large firms as well as of hi-tech and knowledge-intensive sectors. This suggests that with respect to these two innovation modes, both size and industry are not a necessary condition to be associated with faster growth of turnover.

6. Conclusions

The general aim of this paper was to bring design into the realm of the literature that investigates the patterns of innovation at the micro level. This stream of research has so far underestimated the importance of design activity as a key innovation input and source of the competitiveness of the firm. This is at odds with a great body of studies showing the relevant contribution made by design activity in enhancing firm's innovation capabilities and competitiveness. This paper has tried to fill this gap by carrying out an empirical analysis across more than 5,000 European firms by using a fresh Innobarometer Survey carried out in 2009 (European Commission, 2009b).

As a matter of fact, most of the research dealing with design has been so far based on a case study approach. The first part of this paper has tried to generalize the main findings of previous case study research. Accordingly, five prepositions to be tested have been put forward, which have been confirmed to a considerable extent by the results of this study. Specifically, it arises that firms carrying out design activity are more likely to:

- be involved also in R&D activities (mainly in-house);
- carry out process innovation, along with product innovation;
- use IPRs to protect the outcomes of their innovation activities;
- establish collaboration particularly with suppliers.

In the second part of the paper design has been brought into the main picture of innovation modes. A larger set of innovation dimensions have been considered including: different types of innovation activities, R&D activity (in-house and external), collaboration activities, different strategies such as technological opportunities, market opportunities and cost-saving, as well as open innovation practices. Two main findings emerge:

- design activity is predominant in relation to the innovation mode characterized by: *i.* a complex strategy in terms of innovation activities, i.e. technological innovation is coupled with service and organizational innovation; and *ii.* an explorative and interactive attitude in relation to the external environment in terms of establishing collaborations, exploiting technological opportunities and new markets, as well as open innovation practices;
- this innovation mode is associated to a relative better economic performance when compared to the other modes, thus suggesting a positive relationship with the competitiveness of the firm.

The main claim put forward by previous research, that *design matters* as a source of innovation, is confirmed by this paper's results. This emerges in terms of: *i.* the number of firms relying on design as an innovation input; *ii.* proximity with in-house R&D activity as well as both product and process innovation; *iii.* interactions outside the firm's boundaries; *iv.*

economic performance of the firm. However, these results are subject to a limitation. In as much as data does not allow to point out the amount of expenditure of design activities and R&D activities, it was not possible to determine their relative importance. In addition, cross-section analysis does not allow to investigate the phenomenon from a dynamic perspective. It can be that in some industry design plays the major role with respect to R&D activities (and vice versa), in terms of amount of resources, allocation of human resources and impact on firm's competitiveness. More research needs to be done to further investigate the relationship between design and R&D taking a cross-industry perspective, along the following three directions: *i.* the relative importance of R&D, and design and its evolution over time within the firm; *ii.* the presence of systematic differences in terms of R&D and design expenditures; *iii.* the role played by design in fostering firm's competitiveness.

Bearing in mind this limitation, the main contribution of this study resides in its explorative aim over a large sample of firms. Inasmuch as it has succeeded in demonstrating the prominence of design in firms' innovation, it contributed in emphasizing the role of design as a source of innovation which has been so far underestimated in the innovation literature.

The results also suggest some implications in terms of measurement methodology. The important steps forward of the third edition of the Oslo Manual in terms of incorporating non-technological innovation as a fundamental form of innovative activities (OECD, 2005) have been already recognized (Smith, 2005). However, design is considered a sub-product of marketing innovation.[8] This is also reflected in the CIS harmonized questionnaire, which includes a question about design only as part of marketing innovation, and therefore an output. In the light of our results, it is reasonable to suggest including a specific question regarding design separate from marketing innovation and emphasizing its specific nature. [9] However, this should be done once a more accurate definition of design is provided. A suggestion would be to amend the definition of design in the next revision of the Oslo Manual, emphasizing its nature of process and source of innovation. Finally, an important drawback is the European-centric nature of the CIS. It would be extremely valuable to have comparable data also for the US and Japan.

From a normative perspective, this paper's findings are in tune with those scholars claiming the need to broaden the definition of innovation activities beyond the focus on technology and R&D activities. Within this standpoint, this paper's contribution is to add some good reason and sound evidence to take seriously into account the role played by design. This has also policy implications. First, a general acknowledgment of the role that design can play in fostering innovation and firms' competitiveness would be a fundamental first achievement (European Commission, 2009a). Consequently, policy makers need to pay attention to the fundamental role played by qualified human resources in this field. In as much as non-technological forms of innovation become increasingly relevant, we need to bear in mind that the competences and skills which lie behind them can differ from those related to R&D activities. A better understanding of the peculiar features that characterises these innovation activities, and accordingly the "design" of appropriate education and vocational training policies is therefore needed, as long as we believe these forms of innovation are going to play

[8] More precisely: "marketing innovations include significant changes in product design that are part of a new marketing concept. Product design changes here refer to changes in product form and appearance that do not alter the product's functional or user characteristics" (OECD, 2005, p.49).

[9] A good example is the UK version of the CIS, where a new item, named "all forms of design", has been added in the "Innovation activities and expenditures" section. It has been defined as follows: "expenditure on design functions for the development or implementation of new or improved goods, services and processes. Expenditure on design in the R&D phase of product development should be excluded".

a major role in fostering competitiveness and growth, as well as generating new job opportunities in advanced countries.

TABLES

Table 1
Firms, innovation inputs and innovation typologies, frequencies and percentages

Design		*Acquisition of machineries*	
No. Firms	%	No. Firms	%
1,846	43	3747	83
Acquisition of external knowhow		*Marketing innovation*	
No. Firms	%	No. Firms	%
2,525	59	2,407	56
R&D performed in house		*Organizational innovation*	
No. Firms	%	No. Firms	%
2,277	54	2,706	62
R&D acquired outside			
No. Firms	%		
1,498	35		

Table 2
Design innovation and the characteristics of the firm

Variables	
Typologies of innovation	
product innovation	0.55***
service innovation	0.24
process innovation	0.35***
Activities to support innovation	
R&D performed in house	0.59***
R&D acquired outside	0.22**
IPRs strategy	
Application for patents and design registration	1.07***
Collaboration activities in support of innovation activities	
customer	0.17
supplier	0.22**
university and research centre	0.13
other firms	0.11
Size of the firms	
medium size	-0.04
large size	0.37***
Control variables	
innovation intensity low (innovation expenditures between 5% and 25% of total turnover)	-0.35**
innovation intensity medium (innovation expenditures between 25% and 50% of total turnover)	-0.11
innovation intensity high (innovation expenditures more than 50% of total turnover)	-0.27
turnover growth low	0.04
turnover growth high	0.07
industry dummies	included
country dummies	included
Observations	2551

*** p<0.01, ** p<0.05, * p<0.1
Reference categories: Size: 20-49 employees; innovation intensity: low < 5% of the turnover; turnover growth < 0%.

Table 3
Variables and survey questions used in the factor analysis

Typologies of variables	**Variable**	**Survey question**
Sources of innovation		Has your company had expenditures on any of the following activities to support innovation since 2006?
	R&D performed in house	Research & development within your company
	R&D acquired outside	Research and development performed for your company by other enterprises or by research organisations
	Acquisition of know-how	Purchase or licensing of patents, inventions, know-how, and other types of knowledge
	Acquisition of machinery	Acquisition of new or significantly improved machinery, equipment and software
	Design	Design (graphic, packaging, process, product, service or industrial design)
Collaboration activities		Has your company developed any strategic relationships in support of your innovation activities with:
	Customers	• Some specific customers or clients
	Suppliers	• Suppliers
	Other companies in the same field	• Other companies active in your field
	Universities and research centres	• Research institutes and educational institutions
Non-technological innovation		Has your company introduced any of the following innovations since 2006
	Marketing innovation	New or significantly improved marketing strategies
	Organizational innovation	New or significantly improved organisational structures (e.g. knowledge management, workplace organisation or external relations)
Methods in support of innovative activities		
	Patents and design registration	Has your company had expenditures on application for a patent or registration of a design
	Knowledge management practices	Has your company started or increased any of the following initiatives to integrate different company activities (R&D, design, marketing/sales, production etc.) in support of innovation? • Knowledge management systems • Internal mechanisms for employees to submit innovative ideas • Staff rotations or secondments between different functions • Creation of cross-functional or cross-departmental teams on innovation projects
	Open innovation practices	Has your company used any of the following methods **to** support its innovative activities? • Create or participate in internet-based discussion forums • Give away or allow free access to test products or services to potential users • Involve potential users in your in-house innovation activities • Share or exchange your intellectual property
Innovation drivers	Cost reducing	Reduce costs of existing products and services
	Technological opportunities	Emergence of new technologies to be exploited
	Market opportunities	New opportunities to enter new markets or expand sales in existing markets

Source: Innobarometer (European Commission, 2009b).

Table 4
Factor* analysis of the innovation variables: explained variance

Factor	variance	proportion	cumulative
factor 1	3.11	0.18	0.18
factor 2	3.05	0.18	0.36
factor 3	1.99	0.12	0.48
factor 4	1.16	0.07	0.55

* There are several methodologies to rotate a factor loading matrix in order to make results easier to interpret. In this case I used the orthogonal varimax methods, in which the rotated factors are still orthogonal.

Table 5
Factor analysis of the innovation variables: factors loading and unique variances

Variable	technology creation and adoption (factor 1)	interacting and searching out of the boundaries (factor 2)	non-technological form of innovation (factor 3)	cost saving strategy (factor 4)
Marketing innovation	0.12	0.08	0.80	-0.06
Organizational innovation	0.05	0.16	0.77	-0.03
Knowledge management	0.24	0.37	0.52	-0.10
Design	0.60	0.12	0.30	0.20
R&D performed in house	0.75	0.25	0.20	-0.16
R&D acquired outside	0.66	0.20	0.33	-0.30
Acquisition of know-how	0.70	0.12	0.17	0.20
Acquisition of machinery	0.33	0.22	0.18	0.67
Customers	0.15	0.78	0.10	0.03
Suppliers	0.07	0.72	0.16	-0.03
Universities and res. centres	0.43	0.54	0.09	-0.32
Other firms	0.06	0.72	0.08	-0.04
Patents and design reg.	0.79	0.10	0.12	0.03
Open innovation practices	0.30	0.51	0.23	-0.32
Cost reducing	-0.16	-0.13	-0.22	0.49
Technological opportunities	0.24	0.57	0.15	0.12
Market opportunities	0.24	0.40	0.38	0.18

Table 6
The five clusters, frequencies, percentages and cumulative percentages

Clusters	frequency	percentage	cumulated
1	732	23.82	23.82
2	655	23.31	45.14
3	488	15.88	61.02
4	664	21.61	82.62
5	534	17.38	100
Total	3073	100	

Table 7
The characteristics of the five clusters based on the indicator used for the factor analysis

cluster	Marketing innovation	Organizational innovation	Knowledge management	Design	R&D performed in house	R&D acquired outside	Acquisition of know-how	Acquisition of machinery	Customers
1	0.76	0.86	0.76	0.4	0.43	0.21	0.12	0.91	0.86
2	0.10	0.19	0.24	0.32	0.42	0.16	0.17	0.94	0.4
3	0.26	0.36	0.5	0.24	0.70	0.59	0.08	0.49	0.59
4	0.81	0.82	0.54	0.41	0.35	0.17	0.12	0.79	0.14
5	0.8	0.83	0.8	0.86	0.97	0.78	0.34	0.97	0.71

cluster	Suppliers	Universities and res. centres	Other firms	Patents and design registration	Open innovation practices	Cost reducing	Technological opportunities	Market opportunities
1	0.86	0.49	0.66	0.04	0.77	0.28	0.65	0.83
2	0.38	0.18	0.25	0.11	0.29	0.62	0.36	0.52
3	0.67	0.66	0.38	0.14	0.79	0.15	0.38	0.46
4	0.12	0.15	0.07	0.08	0.42	0.34	0.22	0.57
5	0.78	0.78	0.44	0.62	0.85	0.2	0.64	0.86

Table 8
Typologies of innovation by cluster

Typologies of innovation		Cluster					
		1	2	3	4	5	total
product	%	67	59	63	54	88	66
	no.	*464*	*370*	*292*	*346*	*461*	*1933*
process	%	74	53	52	61	85	65
	no.	*529*	*340*	*252*	*400*	*453*	*1974*
service	%	68	47	55	55	65	58
	no.	*488*	*302*	*266*	*357*	*344*	*1757*

Table 9
Size of the firms by cluster

Firm size		Cluster					
		1	2	3	4	5	total
Small	%	40	44	36	43	25	38
	no.	*294*	*289*	*175*	*288*	*131*	*1177*
Medium	%	35	33	35	33	32	34
	no.	*256*	*214*	*171*	*218*	*172*	*1031*
Large	%	25	23	29	24	43	28
	no.	*182*	*152*	*142*	*158*	*231*	*865*
	tot %	100	100	100	100	100	

Table 10
Industry and sector distribution by cluster

Sector and industry	Cluster					
	1	2	3	4	5	*total*
medium-high tech manufacturing	10	15	13	7	19	*13*
medium-low tech manufacturing	29	40	28	29	35	*32*
knowledge intensive service	18	13	24	17	21	*18*
less-knowledge intensive service	43	32	35	47	25	*37*
Coke, petroleum	1	0	2	2	2	*1*
Chemicals	16	21	15	17	22	*18*
Rubber, plastic products	3	6	8	4	4	*5*
Metals	7	7	4	5	8	*6*
Machinery and equipment	4	5	7	4	10	*6*
Radio, television, medical instr, Motor vehicles	2	4	3	1	4	*3*
Furniture, manufacturing nec	2	3	2	2	3	*2*
Electricity, gas water supply	2	2	3	1	1	*2*
Construction	9	11	6	6	3	*7*
Wholesale, retail and trade	25	19	20	31	18	*23*
Hotels restaurants	5	2	4	7	4	*4*
Transport, pipelines	7	7	5	5	4	*6*
Post and telecoms, fin. int., insurance	4	3	5	5	5	*4*
Real estate, renting of mach	2	1	1	1	1	*1*
Computer and related activities, R&D"	2	1	4	2	4	*2*
Other business activities	6	5	6	6	7	*6*
Public administration, educ., health	1	1	4	1	1	*1*
Total	*100*	*100*	*100*	*100*	*100*	*100*

Table 11
Economic performance and innovation modes, ordered logit model (odds ratio and coefficient)

	Model 1		Model 2	
Variables	Odds ratio	coefficient	Odds ratio	coefficient
Innovation modes				
outward non-technological	1.28**	0.24**	1.24*	0.22*
inner non-technological	1.11	0.1	1.17	0.16
technology-focus	0.93	-0.06	0.93	-0.077
multifaceted innovation	1.71***	0.54***	1.72***	0.55***
Control variables				
medium size			1.3***	0.26***
large size			1.23**	0.21**
innovation intensity 1			1.17	0.15
innovation intensity 2			1.78	0.16
innovation intensity 3			2.27**	0.82***
medium-high tech manufacturing			1.29*	0.25*
medium-low tech manufacturing			0.94	-0.06
knowledge intensive service			1.53***	0.43***
Observations		2381		2152

*** p<0.01, ** p<0.05, * p<0.1

Reference categories: Innovation modes: cost-saving innovation; Size: 20-49 employees; innovation intensity: low < 5% of the turnover; macro-sector: less-knowledge intensive service

APPENDIX

Table A1 - Total sample of *innovative** firms by size, industry and country

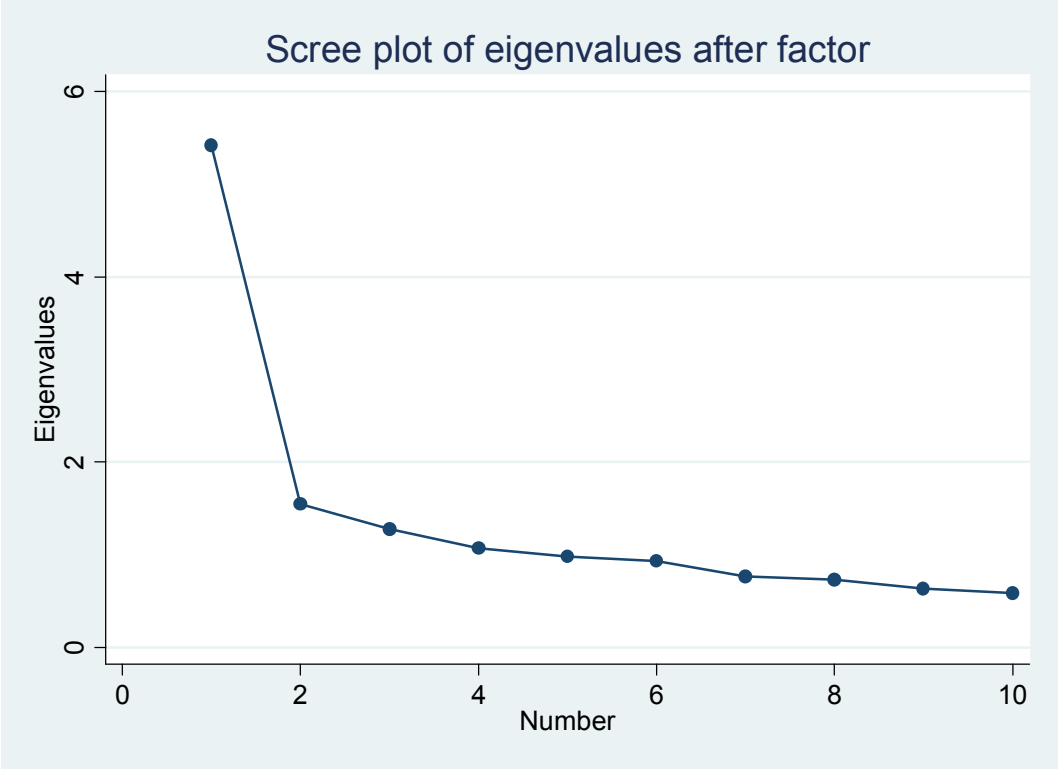
Size of the firm	No. Firms	Countries	No. Firms
Small	1755	Belgium	182
Medium	1524	Czech Rep.	180
Large	1340	Denmark	177
		Germany	183
		Estonia	172
		Greece	184
		Spain	177
		France	173
		Ireland	182
Industries (NACE 2-digit)	No. Firms	Italy	174
		Cyprus	63
23	71	Latvia	164
24	782	Lithuania	180
25	189	Luxemburg	56
27	272	Hungary	140
29	244	Malta	61
30	8	Netherland	182
32	60	Austria	185
34	66	Poland	187
36	112	Portugal	171
40	88	Slovenia	190
45	332	Slovak Rep.	185
50	1,093	Finland	186
55	244	Sweden	187
60	278	United Kingdom	168
65	237	Bulgaria	158
70	55	Romania	184
72	115	Norway	92
74	285	Switzerland	96
75	88		
Total	4619	Total	4,619

Note: "non innovative firms" have been excluded from the sample, that is, those firms which have not reported any innovative activities over the considered period, equal to 615 firms.

Table A2 - correlations of the variables feeding into the factor analysis

	MARK	ORG	KMAN	DESIGN	inRD	extRD	KHOW	MACH	CUSTOM	SUPP	UNI	FIRM	APPR	SHARE	COST	TECHOP	MKTOP
MARK	1.00																
ORG	0.27	1.00															
KMAN	0.20	0.28	1.00														
DESIGN	0.19	0.14	0.17	1.00													
inRD	0.12	0.11	0.24	0.28	1.00												
extRD	0.11	0.12	0.20	0.21	0.39	1.00											
KHOW	0.11	0.12	0.17	0.21	0.24	0.21	1.00										
MACH	0.08	0.09	0.13	0.18	0.16	0.10	0.15	1.00									
CUSTOM	0.12	0.15	0.23	0.17	0.22	0.15	0.16	0.06	1.00								
SUPP	0.14	0.14	0.20	0.16	0.15	0.14	0.10	0.09	0.39	1.00							
UNI	0.13	0.14	0.25	0.18	0.31	0.31	0.19	0.08	0.29	0.21	1.00						
FIRM	0.11	0.11	0.20	0.11	0.13	0.13	0.12	0.07	0.32	0.28	0.29	1.00					
APPR	0.11	0.08	0.13	0.31	0.26	0.22	0.40	0.08	0.16	0.12	0.19	0.11	1.00				
SHARE	0.15	0.14	0.25	0.18	0.24	0.21	0.17	0.06	0.28	0.23	0.29	0.21	0.17	1.00			
COST	-0.08	-0.06	-0.10	-0.09	-0.11	-0.08	-0.06	-0.02	-0.11	-0.08	-0.11	-0.08	-0.09	-0.13	1.00		
TECHOPP	0.12	0.09	0.23	0.14	0.20	0.16	0.16	0.16	0.24	0.20	0.24	0.19	0.14	0.24	-0.12	1.00	
MKTOPP	0.19	0.14	0.21	0.18	0.18	0.12	0.15	0.12	0.22	0.16	0.14	0.13	0.14	0.22	-0.11	0.27	1.00

Figure 1A



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