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# Design and European firms' innovative performance: Evidence from European CIS non anonymous data

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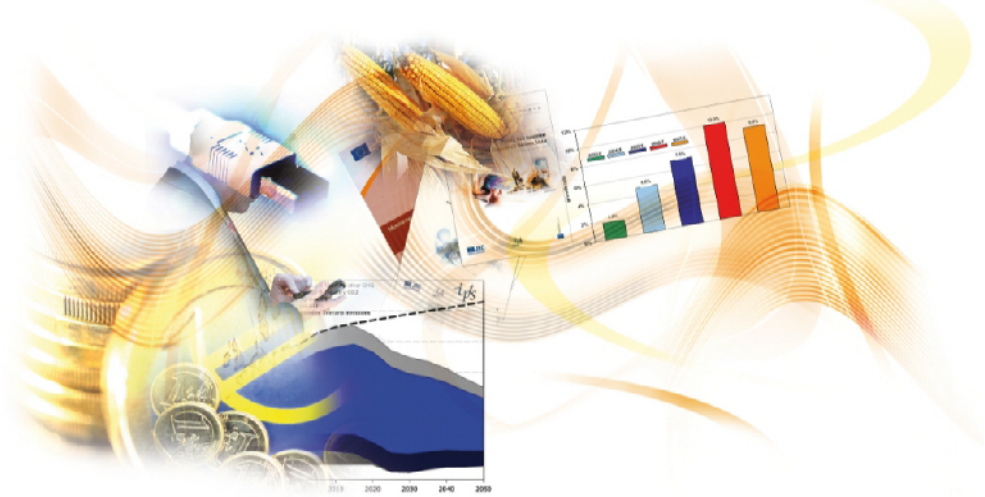

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# Abstract

The objective of this study is to provide an analysis of the importance of design – defined as the procedures, choice of elements and technical preparation to implement a new product – and R&D investments as drivers of European firms' innovation performance. In doing so, it partly compensates for the lack of empirical evidence in the literature by using non-anonymised data from the third wave of the European CIS, and estimating a system of simultaneous equations to tackle the endogeneity inherent in these investment choices and the externalities associated with them. The choice to use this time period rather than more recent is data-driven as this wave contains better information on design expenditures. Unlike the majority of CIS-based studies, the main variables of interest are continuous ones. In addition, although pure aesthetic changes are not included in the CIS definition of innovative design expenditures, the impact of this important dimension of product innovativeness is properly accounted for. The robustness of results confirms the crucial role of design investment for innovation success in 23 European countries for both the manufacturing and service sectors and its role as a complement to technological R&D and as a driver for user-centred incremental (new-to-the-firm) and radical (new-to-the-market) innovations. In particular it found an increase of 1% expenditure increases innovation sales by between 0.34% and 0.49%, while the same increase in R&D investment increases innovation sales by between 0.64% and 0.86%. Interestingly, while investing in design shows no statistically different innovation output returns for small, medium-sized and large enterprises, this is not the case for R&D expenditures. The policy conclusions are clear: design is a less costly alternative to R&D for many SMEs and a policy of supporting design should be considered, as this might be a more cost-efficient support strategy.

**JEL Classification:**

**Keywords:** Intangibles, design, R&D investment, CIS, CDM model.

# 1 Introduction

The Innovation Union repeatedly pointed out that many companies are innovative even though they do not perform R&D and that policies attempting to realize their innovative potential, especially that of SMEs, need to recognize the variety of ways - such as design - in which firms innovate (Europe 2020 Flagship Initiative, 2010). In fact, it is widely accepted that expenditures in design may increase the novelty of a new product (as with marketing or R&D expenditure) or increase its user-friendliness. These are the channels through which creativity reaches the market and are an integral part of the development and implementation of product innovations (OECD, 2005) especially now that the globalisation have fragmented the markets into ever-smaller niches (Schilling and Hill, 1998).

Although there is general agreement that rational, well-planned product development (design) and technological innovation play a crucial role in improving the competitiveness of products, firms and national economies (Hertenstein et al., 2005; Roy and Riedel, 1997; Urban and Hauser, 1993; Rothwell and Gardiner, 1983), and that between 75% and 90% of a product's cost is predetermined when the industrial design is finished (Hertenstein and Platt, 1998), solid and influential references on company strategies towards design investments and their impact on a firm's performance are scarce (Walsh, 1996; Acha, 2008). In addition, a clear view on its impact on a firm's performance is made it difficult by the lack of a common definition and understanding of design. Is it an activity (*to design)* and/or the result of this activity? (*design)* (Roy and Riedel 1997, Talke et al., 2009). This has also hindered the gathering of reliable and comparable statistics on these expenditures[1].

The present study aims at partly compensating for the lack of international and cross-sector empirical evidence on the return to design expenditures by emphasizing *design* – defined as the procedures, choice of elements and technical preparations to implement a new product – as a driver of product innovation, alongside complementary to R&D investments (Milgrom and Roberts, 1990, 1995; Tolke et al., 2009). It focuses on the impact of intangible investment[2] (including design) on a firm's performance (Winter, 1987; Kogut and Zander, 1992; Conner and Prahalad, 1996; Barney et al., 2001), and stresses how a well planned

[1] Although there is a way to calculate the return on investment (ROI), there is not yet a way to calculate a firm's return on design, or even to determine what proportion of the total investment is really design (Hertenstein et al., 2001). Therefore, unless this information is made available in a commercial dataset or in a survey, obtaining a value for the investment in "design" is not straightforward.

[2] Intangible capital comprises investment in R&D, innovation and technology development, training, education and skills of workers, internal organisation structures (perceived organisational culture, organisational processes and routines; Barney et al., 2001, p. 625), customer and institutional networks, market exploration and development (marketing) and software and information technologies.

product development process contributes to differentiating the product, and creating a specific-to-the-firm competitive advantage. Design investments contribute to build a firm's comparative advantage creating firm-specific knowledge, which is tacit and not easily transferable and constitute a fundamental firm's resources (Penrose, 1959; Wenerfelt, 1984; Rumelt, 1984; Barney, 1986; Dierickx and Cool, 1989; Peteraf, 1993).

In particular, this study investigates if the success of an innovation (whether new-to-the-firm and/or new-to-the-market) is solely explained by R&D expenditures, or if it partly depends on the industrial design and product development of the innovation itself and on changes in its aesthetic appearance. This study also specifically addresses the fundamental issue of the impact of a firm's size on the returns to design. In fact, although the literature generally confirms an association between design expenditures and a firm’s business and innovation performance, it does not provide a clear-cut prediction on how returns to design expenditures differ according to the size of the firm. Given that small and medium-sized enterprises constitute 99% of European businesses and provide two out of three private sector jobs in the EU[3], this paper assesses whether the elasticity of innovative sales to design expenditures differs between European small and medium-sized and large enterprises. As design represents only a part of the R&D cycle and does not require scientific knowledge or sophisticated technological equipment, it may be particularly relevant to SMEs due to its lower capital intensity and short pay-back period (less than two years), with respect to R&D (French Ministry of Economy, 2002; European Commission, 2009).

The study pursues these aims using non-anonymised data from the third wave of the European CIS[4]. This covers the years 1988-2000 and 23 European countries (Belgium, Bulgaria, Czech Republic, Germany, Denmark, Estonia, Finland, France, Greece, Hungary, Iceland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Portugal, Romania, Slovenia, Slovakia, Spain and Sweden),. This wave was chosen ahead of more recent ones due to the more detailed information on design expenditures available and has been elaborated at the Eurostat SAFE centre in Luxembourg. Unlike the majority of CIS-based studies, this meant continuous variables could be used for both R&D and design expenditures. Although pure aesthetic changes are not included in the CIS definition of innovative design expenditures, the impact of this important dimension of product innovativeness is properly accounted for. Therefore, unlike the majority of empirical research in this field which often focuses either on design as product development or as a pure product's aesthetic appearance or on R&D, this study uses a multi-dimensional approach to

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[3] In the past five years, 80% of new jobs in Europe have been created by SMEs. Structural Business Statistics Database (Eurostat). http://epp.eurostat.ec.europa.eu/portal/page/portal/european_business/data/database

[4] The research was carried out at the Eurostat’s safe centre in Luxembourg.

product innovation and to its impact on innovative sales, by considering both its technical (R&D investment and design as a product development process) and non-technological dimensions (design as a product's aesthetic appearance).

The remainder of this article is organised as follows: Section 2 reviews the different definitions of design and the empirical literature on its impact on firms' performance; Section 3 develops an econometric model to analyse the complementary relationship between design, R&D and innovation following the approach of Crepon et al. (1998); the results are discussed in section 4; and, finally, section 5 focuses on the policy implications of the study.

# 2 Literature review

The possibility of analysing a firm's design investment and its impact on market performance within a common theoretical framework is complicated by at least three problems. First of all, as previously highlighted there is a lack of a common definition of design activities. Secondly, the main strands of the literature that analysed the topic have different units of analysis (products, firms, sectors) and, consequently, use very different methodological approaches. Thirdly, there is a lack of agreement on the channels through which design activities can be used to improve product competitiveness (Roy and Riedel, 1997). In fact, a firm may decide to invest in design and/or research and development to reduce its costs, to improve the quality of its products, to differentiate its products from those of competitors or offer a completely new product[5]. Furthermore, design may be seen as a "lead user" innovation, where lead users are individuals or organisations that need a given innovation earlier than the majority of the target market (Von Hippel, 1986). Finally, designing products with other features superior to those of competitors (e.g., aesthetically, in ease of use or quality) may enable the firm to charge higher prices than competitors and consequently improve its financial performance, which is consistent with Porter's (1980) concept of product differentiation (Hertenstein et al., 2005). Broadly speaking, the more economic-oriented approach of the literature favours design as a tool for product differentiation, while the innovation-oriented literature favours it as an innovation activity. Within the organisational strand of research, the management oriented approach considers design as lead user innovation; while the new product development approach tends to be broader, including cost, efficiency and user needs among reasons for a firm to invest in design.

[5] Therefore, industrial design may affect both a firm's price and non-price competitiveness. In the former case, it may do so through its influence on how economic the product is to manufacture and its life-cycle cost to the

The present study departs from the new product development (NPD) literature and the economic empirical research on the impact of design expenditures on a firm's innovation performance and builds on the theoretical idea of complementarities in production (Milgrom and Roberts, 1990, 1995) and innovation (Acemoglu, 1988). Innovation research on new product development splits into two broad areas of enquiry (Adler 1989; Brown and Eisenhardt, 1995): an economic approach and an organisational one, commonly known as the new product development approach. While the prevailing definition of design is that of industrial design in the economic literature on innovation, in the most organisational-oriented literature, design tends to be defined as the activity of new product development (of which industrial design is a part). The first tradition examines differences in the pattern of innovations across countries and industrial sectors, the determinants of a firm's propensity to innovate and its effect on a firm’s performance. The product development literature focuses on how specific products are developed within a firm and on the project team itself (who actually do the work of product development). The focus of this primarily exploratory and empirical strand of research (Brown and Eisenhardt, 1995) - which has led to a comprehensive overview of the product development process - is generally on the financial impact (profitability, market penetration, revenues) of new product development processes. At the same time, both strands of research largely neglect the performance effect of the novelty of a product design (Talke et al., 2009). This is seen as part of the firm innovation activities only to the extent that it significantly changes a product as a vehicle to visualise an unobservable technological innovation at the component level (Talke et al., 2009). To sum up, each strand of research tends to highlight one aspect more than the others and the results obtained cannot easily be generalised.

As far as the empirical research is concerned, studies in the economic-oriented strand are often confined to a few industries and firms within those industries (Hertenstein et al., 2005; Roy and Riedel, 1997; Roy and Potter, 1993; Tolke et al, 2009; Verganti, 1996), or to a specific country (Haskel et al., 2005; Tethel, 2005). Furthermore, as the boundaries of design are not precise (Walsh, 1996), due to it overlapping with R&D and marketing activities, results obtained from surveys aimed at measuring a firm’s commitment to it are inconsistent (Tether, 2005), with attitudes and strategies towards design varying significantly among firms (Walsh, 1996). Studies in the new product development empirical field are mainly explanatory and generally lack a well-defined theoretical construct (Brown and Eisenhardt, 1995). They are also product-based and use questionnaires and/or interviews asking respondents to explain why a product succeeded or failed, using a wide spectrum of internal

user; whereas for non-price competitiveness, it may do so via its impact on product performance, reliability, and external factors. In the end, it is not unusual to find a set of 10 to 20 or even 40 factors affecting the success of a product.

Within the broad area of NPD research, the so-called rational plan strand is particularly relevant to this study, as it stresses that successful product development is the result of rational planning and execution, and points out the role of the complementary nature of the different innovation activities of a firm. Stated simply, successful products are more likely when the product has market place advantages, is targeted to an attractive market and is well executed through excellent internal organisation (Brown and Eisenhardt, 1995), based on competent and well-coordinated cross-functional teams. In fact, the functional diversity of teams with members from areas such as R&D, marketing, etc increases the amount and variety of information available to design products (Dougherty, 1992). This in turn helps team members understand the design process quicker and more fully, and enhances the design process performance (Clark and Fujimoto, 1991; Zirger and Maidaque, 1990). All in all, the rational plan of the research team tries to verify the theoretical links between internal processes, effective products, and a product's financial performance. However, the methodology used (subjective retrospective responses by single informants and bivariate analysis) does not allow the robustness of the links found to be verified (Brown and Eisenhardt, 1995).

The NPD field of research seems to suggest that complementarities among a firm's activities and departments enhance product development success, in line with the theoretical and empirical findings of part of the economic strand of research on innovation (Acemoglu, 1988; Antonelli et al., 2010; Guidetti and Mazzanti, 2010). For instance, using British data, Lambert (2006) indicated that design inputs into the innovation process have most impact when used with more technological-based inputs, suggesting that, although design and technology are different forms of activity, they complement each other. Another UK study, using the UK CIS 4, showed that there are very few innovating firms engaged in design activities which do not also invest in R&D, and that those involved in these two and other innovation-related activities – such as marketing – are more likely to innovate than those firms that invest in only one of them (Tether, 2006). Haskel et al. (2005) analysed the relationship between design inputs and other innovation and economic performance indicators provided by the third wave of the UK Community Innovation Survey (CIS). As opposed to the CIS conducted in other European countries (and the European one available at the Eurostat Safe centre), the UK CIS treats design separately from other R&D activities by asking companies for design expenditure. Estimating a knowledge production function, an output production

appearance, safety and ease of use, etc (Roy and Potter, 1993).

function and a design expenditure function, Haskel et al. (2005) concluded that design had a positive and statistically significant association with product innovation, though not with process innovation, and that design expenditure had a marginal return of about 17%, with a very short pay back period. Furthermore, they found that around 9% of firms reported some spending on design, and that design spending represented about 10% of all reported spending on innovation activities. A Danish study (Danish Design Group, 2003) which surveyed 1,074 Danish firms with 10 or more employees showed that on average firms that see design as innovation and as a process tend to outperform those with no commitment to design (in sales growth, employment growth and exports). In addition, a report by the OECD on small and medium-sized enterprises (2000) stressed how SME innovation in particular is strongly based on innovation activities other than R&D. In line with these findings, a French study pointed out that this prominence of design investment in SMEs may be due to their lower capital intensity (with respect to R&D) and to the short (less than two years) pay-back period (French Ministry of Economy, 2002). In line with these findings, other authors have stated the advantageous effect of a high degree of technical innovation for a firm's performance (Cooper and Kleinschmidt, 1991; Lyinn et al., 1996; Veyzer, 1998). Gemser and Leenders (2001) found that integrating industrial design into new product development projects significantly and positively influenced Dutch companies' profits, turnover and export sales. Generally speaking, research findings in the economic/innovation literature are sensitive to several factors, such as the industrial design measure selected, the industry coverage, the sample composition (number and size of firms considered), the length of the period analysed and the comprehensiveness of the financial performance measurements used (Hertenstein et al., 2005). However, as a general conclusion, the empirical evidence in the field points out that industrial design is not widely employed, especially from service industries, and that only a small percentage of manufacturing firms utilise the potential it has to offer (Moody, 1980; Walsh, 1996; Tether, 2005).

NPD and innovation literature have also both largely neglected the performance effect of a product's design novelty (Talke et al., 2009), although there are a number of economic-oriented empirical research studies analysing its positive impact on a firm's performance. In fact, this neglect does not imply that this aspect of product innovation is not crucial for product success[6]. In a study focusing on the German automobile sector during the years

[6] Part of the consumer and design research literature argues that aesthetic changes in the visual appearance of a product can directly address consumer needs or may be considered valuable in themselves (Yalch and Brunel, 1996). Furthermore, it is widely recognized that design innovation attracts the attention of consumers, especially if a product's design deviates significantly from existing products (Garber, 1995; Schoormans and Robben, 1997). At the same time, as well as these arguments suggesting an overall positive effect for design innovation on performance, it may be argued that a unique design would not be easily

1978-2006, Talke et al. (2009) emphasized that both design (defined as the aesthetic appearance of the product) and technical innovation (defined as the introduction of new technological principles, architecture, components or materials in a product; Gemunden, Salomo, and Krieger, 2005) are important drivers of car sales, although their effect differs widely across the product life cycle. In fact, pure design innovation has a positive impact immediately after launching the product on the market, and is persistent over time; while there is a lag in the effect of technical innovation on sales, and a decrease towards the end of the life cycle. Overall they conclude that the different appearance of a new product is fundamental to increasing its performance, as well as technical innovation, even in a high-tech sector such as the automobile industry. Furthermore, the empirical evidence in Talke et al. (2009) has two interesting considerations. First of all, it suggests the change in the effects of aesthetic appearance and technical innovation on sales over the product life cycle show that these two "innovation" parameters complement each other. Design innovation has an immediate effect in helping to create awareness among consumers which remains constant over the product life cycle; whereas technical innovation needs time to reach its full effect, and the magnitude of this effect declines over time. However, they both contribute to product competitiveness: launching products which are more technologically advanced than competitors' products boosts sales performances. Secondly, the lag shown by technical innovation may suggest that consumers need time to obtain information about the novel technical features of the product. In this respect, Garcia (2011) found that marketing a new product significantly boosts European firms' innovation sales, so investing in marketing a product may reduce this time lag, especially if it is a new-to-the-market product.

This study contributes to the aforementioned research fields by proposing an empirical model based on the complementary nature of innovation and product-based competitive advantage of firm-specific resources, such as the organisational practices and routines (Nelson and Winter, 1982) generally involved in product development (Barney et al., 2001). This model is used to gain a better understanding of the relative importance of a firm's structural features (size, industrial specialisation, if it belongs to a group, its presence in international markets) and intangible parameters for deciding the resources to allocate for design, and to determine the extent to which this investment affects the innovative market performance of the firm, *together with* R&D.

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accepted by consumers. This is shown in the Schoormans and Robbens (1997) study on the consumer response to novel ground coffee packaging, and is also argued by Tolke et al (2009) and Snelders and Hekkert (1999).

# 3 Methodological approach

From the previous discussion it emerged that when modelling the impact of design and R&D investment on a firm's innovation performance, there are a series of aspects to be considered, apart from their endogenous character (Crepon et al., 1998). Firstly, design investment is usually complementary to intangible investment in areas such as R&D and marketing (Guidetti and Mazzanti, 2007) and both product development and pure product design are likely to have a positive impact on a firm's financial and innovation performance (Talke et al., 2009). Secondly, there are differences in design depending on the company size, sector, and international and innovation orientation. Thirdly, investments in design and R&D are likely to produce positive externalities and affect the firm's competitors. In other words, the investment made by a firm may generate profits for other firms in the same sector or region (Breschi and Lissoni, 2001) through knowledge spillovers, spin-offs and other informal mechanisms (e.g., interpersonal contacts, face-to-face communication, meetings and seminars). Finally, R&D and design investments are likely to be endogenous as firms determine their investments in R&D and design at the same time, so factors affecting one decision might also affect another (e.g., a large firm will have higher investments in R&D and higher design expenditures).

To tackle these issues, a system of three structural equations based on the approach of Crepon et al. (1998) was prepared. The system followed the interpretation of the relationship between design, innovation and competitiveness, according to which design activities links creativity to innovation (Swann and Birke[7], 2005). Within this methodological framework, tailored to take advantage of the innovation survey data, endogeneity and selectivity are specifically taken into account. The model is structured as follows:

$$
\begin{array}{lll}
DS = DS^* & \text{if} & DS^* = \beta_{1TR} z_1 + \beta_{2TR} z_c + \varepsilon_{TR} \geq 0 \\
0 & \text{if} & DS^* = \beta_{1TR} z_1 + \beta_{2TR} z_c + \varepsilon_{TR} < 0 \\
RD = RD^* & \text{if} & RD^* = \beta_{1rd} DS^* + \beta_{2rd} z_2 + \beta_{3rd} z_c + \varepsilon_{rd} \geq 0 \\
0 & \text{if} & RD^* = \beta_{1rd} DS^* + \beta_{2rd} z_2 + \beta_{3rd} z_c + \varepsilon_{rd} < 0 \\
INNO = INNO^* & \text{if} & INNO^* = \beta_{1INNO} DS^* + \beta_{2INNO} RD^* + \beta_{3INNO} z_3 + \beta_{4INNO} z_c + \varepsilon_{INNO} \geq 0 \\
0 & \text{if} & INNO^* = \beta_{1INNO} DS^* + \beta_{2INNO} RD^* + \beta_{3INNO} z_3 + \beta_{4INNO} z_c + \varepsilon_{INNO} < 0
\end{array}
$$

Where DS* is the latent design effort and RD* is the latent innovation effort from the first and the second steps; $z_1$, $z_2$, $z_3$ are vectors of explanatory variables specific for each equation; $z_c$ is a common control variable vector; and $\varepsilon_{TR}$, $\varepsilon_{HK}$, and $\varepsilon_{INNO}$ are normally distributed error terms with zero mean and $\sigma^2_t$, $\sigma^2_h$ and $\sigma^2_i$ standard deviation, respectively. Unlike Heckman's selection models, no correlation between the selection error terms and outcome equations is allowed, while a latent variable is estimated for design and R&D for every firm in the sample (see Garcia, 2011) and introduced in the third equation, which was estimated with and without bootstrap re-sampling procedures[8] (Efron 1982) using 50 replications to check for robustness and consistent estimates. The use of the two latent variables (DS* and Rd*) and not their observed values is justified on both methodological grounds (as the only way a system can be defined using non-linear estimations) and theoretical grounds (i.e., based on the existence of external knowledge flows). It also implies that the sample is not restricted to firms performing design and R&D as the inclusion of the predicted design and R&D effort in the regression accounts for the fact that all firms may have some kind of innovation effort, even though only some of them invest in R&D and/or design and report it (Hall et al., 2009). Moreover, using the predicted values and not the actual ones is also a sensible way to measure innovation in the knowledge production function, to deal with the simultaneity issue between R&D/design and the expectation of innovation success (Hall et al., 2009).

To sum up, the first equation (DS) links a firm's design investment to its determinants, and describes the design investment and product implementation procedures; the second equation (*RD*) represents the R&D relationship and the link between design activities and creativity (intramural and extramural research and development expenditures); finally, the third equation (*INNO*) relates design and research to innovation output, namely product innovation measured as innovation sales. Therefore, the model summarises the processes used by the firm in deciding how much to invest in the industrial design of its products and research activities for the introduction of new-to-the-firm and new-to-the-market innovations. As far as their measurement is concerned, *DS* is the natural logarithm of the firm's design expenditure in 2000; *RD* is the natural logarithm of the amount of intramural and extramural research and experimental undertaken by the firm in 2000; and *INNO* is the natural logarithm of the firm's innovation sales in 2000. As previously mentioned, two different measures of INNO were calculated, one referring to new-to-the-firm products, and the second referring to new-to-the-market products.

The theory behind it is as follows: R&D involves the scientific creativity of a firm, while investment in design is the effort made by the firm to transform these new ideas into new products. Product development procedures are fundamental to exploit the full potential of R&D investments and, at the same time, R&D and investments in design are both critical to

[7] In the UK Department of Trade and Industry (DTI), 2005.

the success of innovative firms (Hertestein and Platt, 2000), as are those activities related to the product development process which transforms concepts into commercially viable products. It follows that the third equation shows that creativity and design are linked to innovation (Bitard and Basset, 2008) which is the exploitation of these ideas. In this third equation, pure product design is inserted in $z_3$ to represent the multi-dimensional nature of product innovation and its correlation with market success. In fact, creativity “contributes to the expansion of available ideas” whereas design increases the “chance of successfully commercialising these ideas” (Hollanders and van Cruysen, p. 6, 2009). Furthermore, the complementarity of R&D and design is due to the fact that changes in product design may involve the creation, modification or adoption of new technologies or innovations in materials or components. Not addressing this complementarity with a proper methodological framework would result in an incomplete understanding of the determinants of a firm's innovation performance.

The three relationships are estimated with a generalised tobit model (Crepon *et al*., 1998) because, although the sample is restricted to innovative firms, a large proportion of these reported zero expenditures on design and/or R&D expenditures or zero innovative sales[9], and performed for new-to-the-firm products and, as a robustness check, for new-to-the-market products. Standard checks for outliers were performed and only very few abnormal values of design expenditures were identified (and removed from the observations). Finally, it is worth noting that given the cross-section structure of the CIS, the causality links between variables are generally thought as "weak links", and that the objective of the following analysis is not to test cause-effect relationships, but to assess the significance and intensity of the correlation relationships between the main variables of interest.

## 3.1. Measurement issues

The Community Innovation Survey is coordinated by the European Commission and carried out by the Member States. In most cases, it does not distinguish design from R&D or marketing activities, and does not provide the amount spent by firms on them. However, the third wave of the CIS is an exception to a certain extent. Before explaining how the amount spent on design was calculated, it must be clarified that, in this study, the design investment is the expenditure on the procedures and technical preparations to implement the actual products (goods and services) and process innovation, which is not covered elsewhere in

[8] Results do not significantly differ, and are available on request.
[9] Consequently, the three dependent variables are censored variables, and the three equations are tobit.

CIS 3. In other words, design expenditure is defined in the CIS 3 as all expenditure due to production changes and the quality control procedures, methods and standards and associated software required to produce new products or processes (namely, tooling up and industrial engineering, see OECD Oslo manual, 1995); industrial design investment, namely the plans and drawings to define procedures, technical specifications and the operational features required for the production of technologically new products and the implementation of new processes (see OECD Oslo manual, 1995); expenditure for testing technologically new or improved products or services, and for acquiring the machinery, tools and equipment for the implementation of new or improved products or services. Therefore, the CIS definition of design is broader than the "industrial design" definition normally used in the economic empirical research, and closer to that of product development. As some of the activities generally considered to be part of the product development process overlap with the initial R&D phase, some industrial design activities (such as prototyping and industrial design required during R&D) are included in the definition of R&D according to the OECD (2002 and 2005). As the CIS structure follows the Frascati and Oslo manual definitions of R&D and innovation, all stages of new product development are included, with limited problems of overlap between design and R&D. Moreover, design expenditure according to the CIS does not overlap with marketing expenditure, as there is a direct question on each in the same section, where firms are asked whether they spent on design or not. On the one hand, the broad definition of design in the CIS reflects the idea that design is a comprehensive approach to the development of products, services and systems, and that the concept of design develops from results (the product) to processes (conception & production), as well as design being an isolated corporate activity for user-centre “design thinking”. On the other hand, this definition implies that those artistic activities undertaken *only* to improve the appearance of the product (Talke et al., 2009) *without* any objective change in its performance are not considered as part of the technological product and process innovation, and are therefore not included in the definition of design used in the following sections. However, from the CIS it is possible to identify those firms that introduced pure aesthetic changes to their products, although in this case no information on the amount of expenditure is given. Consequently, this aspect of non-technological product innovation is controlled for by a dummy variable, as is explained in section 3. For the sake of clarity, therefore, the CIS definition of innovative design expenditure (DS; see section 3.2) is taken as the definition of design investment (or innovative design) in this study, while product design (*actaes*; see section 3.3) refers to the aesthetic changes in the appearance of a product.

Although the CIS definition of design for this category of expenditure is clear, measuring it within the CIS 3 is not a trivial matter. In fact, among those firms that engaged in technological innovation between 1998 and 2000 (20,920 out of 61,540[10] firms were innovators under the CIS definition), the CIS[11] asked if a firm invested in training, marketing and/or design in 2000. Unfortunately, the only information available at the Eurostat safe centre was the overall expenditures on these innovation related activities (labelled *rothx* in CIS 3, which is not available for later waves of the CIS). To correctly identify them and obtain a continuous variable, only those firms that declared to have invested in design in the questionnaire and did not invest in marketing and training were considered. As a consequence of this, the amount invested in innovation is, by definition, the amount reported in *rothx*. Clearly, this option underestimates the number of firms that actually invested in design, as those that invested also in marketing aimed directly at launching new or significantly improved products *and* training were not considered. On the other hand, this simpler option meant a firm's expenditure in design could be obtained and the direct and indirect effects of this investment on innovation sales could be isolated. Furthermore, the identification method used reduces the likely underestimate of design expenditures, which might be more probable in firms where R&D and/or marketing have a higher status than "design" (Tether, 2005). In fact, the extent to which firms record design expenditures may be a pure matter of opinion, as some design expenditures might be included under R&D and/or marketing (Tether, 2005). If a firm employs people in design, marketing and R&D and some overlap of these functions (or departments) exists, design expenditure may be under- or overestimated. If R&D and marketing are prominent functions, design may be *silent* (Gorb and Dumas, 1987)[12] or *hidden* within these functions. If, however, design is acknowledged as a prominent activity, some R&D and marketing may be included within the design function or department.

Overall, 9,118[13] firms (more than 58% of the product innovators) declared having engaged in design-related innovation procedures and technical preparation for implementation of goods and services in 2000. Of these firms, 5,134 engaged in training, marketing and design; 1,052 engaged in design and marketing, but not in training; while 1,487 engaged in design and

[10] The original dataset was removed for firms that reported zero turnover or zero employees.

[11] The UK CIS is an exception as it treats design separately from other R&D activities by asking companies for design expenditure.

[12] Gorb and Dumas (1987) pointed out that design is often undertaken by people who are not recognized as designers. Therefore, part of the firm's design efforts is likely to be "silent" and be under- or not recorded. The authors defined silent design as design and development work included in marketing, production and other departments, even though it may not be officially designated as design. See also Tether (2005).

training, but not in marketing. Finally, 1,445 firms in 2000 (9.2% of the product innovators in the dataset) declared having engaged in design activities only (see Table 1). This sub-sample was used to identify the features of a firm that invested in design. Almost 89.5% of firms that spent a positive amount on design activities in 2000 were small and medium-sized enterprises (according to the EC definition: number of employees <250 and sales ≤50,000,000), with about 10.5% being large firms. The average expenditure on design is €19,500 (for those firms that declared a positive amount of investment on design in 2000, and did not invest in training and marketing at the same time).

As far the other two dependent variables are concerned, *RD* is the natural logarithm of the expenditure in external and internal R&D in 2000, and *INNO* is the natural logarithm of firm's innovative sales[14] (which measure product innovation) firstly calculated in a way to account for incremental innovations, and then calculated to account for breakthrough innovations. In fact, INNO is calculated multiplying the share of new or significantly improved products/services introduced during the period 1998-2000 (*turnin* in the CIS questionnaire) by the firm's 2000 total turnover to obtain the *innovative to the firm sales* and multiplying the share of new for the enterprise's market (or significantly improved) products/services introduced during the period 1998-2000 (*turnmar* in the CIS questionnaire) by the firm's 2000 total turnover to obtain the *innovative to the market sales*. The decision to use innovation sales is due to the focus in the study on how a firm may increase new product sales, by emphasising project management once the ideas are proposed. Overall, the suggestion is that a strong product development process, R&D expenditures and an aesthetically attractive product should lead to a successful product, and to a larger amount of innovative sales.

## 3.3. Econometric model

The explanatory variables included in the system of equations that, according to the relevant literature, may play a role in a firm's decision to invest in design and R&D, and affect its innovative performance, are explained below. However, before explaining the theory behind their selection, it must be pointed out that some exclusion restrictions were imposed to ensure parameter identification in each of the three equations. The choice is partly motivated on theoretical grounds (i.e., design expenditure might be more relevant for a firm that relies mainly on its customers for information about product innovation, whereas cooperation may

[13] Actually, the number of firms who answered the survey question regarding their involvement in design-oriented innovation in 2000 was slightly higher (9,204). Once the answers for training and marketing activities were considered, the number of firms for which data was available was 9,118.

be more important for R&D itself), but it is also based on data constraints and the significance of the estimated coefficients, as non-significant coefficients might be poor instruments for identifying other key parameters in the model (Greene, 2007).

For the sake of simplicity, in the following I firstly describe the variables which are common to the entire set of equations ($z_c$), and secondly the set of variables specific to each equation ($z_1$, $z_2$, $z_3$). Both the choice of the common factors affecting firms' choices ($z_c$) and of the control variables included in $z_1, z_2, z_3$ are based on the literature. Table 2 describes the dependent and explanatory variables included and the usual descriptive statistics. To check for robustness, four slightly different systems of equations were estimated, whose differences are illustrated in Table 3. In the following, the names of the independent variables used are reported in brackets and *italics*.

As far as the model specification is concerned, the common set of independent variables ($z_c$) includes the firm's size (*lnempl*), 23 country controls (*dummycountry1- dummycountry23*), 9 sector controls (*nacemht-nacehtserv*; see Table 2 for a description) and a dummy for whether a firm belongs to a group or not (*group*). The control for the size of the firm was introduced because it is generally recognized that large firms tend to better exploit economies of scale and scope. Smaller firms are more flexible but often tend to have limited resources and competences, and fail to exploit economies of scale (Lichtenberg and Siegel, 1991). Larger firms usually have easier access to finance through reinvested profits and bank loans to finance expensive innovation. Yet there may be diminishing returns to R&D, which affect large firms more than small firms and, consequently, reduces the R&D advantage of large firms (Acs and Audretsch, 1991). As the overall quality of the educational system, the openness of the society towards different countries and culture determine a country's creative climate[15] (Hollanders and van Cruysen, 2009), country dummies were included for heterogeneity, as more creativity results in a stronger creative sector and higher levels of creativity in R&D and design. At the same time, these country dummies control for differences in IPR regimes, which have a fundamental role in creating incentives for firms to adopt new methods of production and new knowledge (Howkins, 2005). To minimise the effects of industry-specific factors of production and structure, sectors were controlled for by inserting dummies for low, low-medium, medium-high and high-tech manufacturing and service sectors, following the Eurostat classification. As far as the sector controls are

[14] In both cases I calculated the log of (innovative sales + 1) and the log of (R&D personnel + 1). Laursen and Salter (2003).

[15] A creative environment attracts talented and ambitious people, who bring new ideas and different world views (Stolarick et al., 2005). This cultural diversity provides sources of creative expression which are then captured by the creative industries (Hollanders and van Cruysen, 2009; Bell and Stolarick, 2008; Florida, 2002).

concerned, it is often argued that some industries have higher or lower average R&D "by nature", and that a firm's sales of new products are decisively influenced by the typical length of the product life cycle (Paananen and Kleinkneicht, 2010). Therefore, firms with shorter life cycles will introduce new products more often and have higher shares in total sales of such products than firms whose products have a longer life cycle. Also, according to the research-based view of the firm, for intangible resources to be a source of superior firm performance, the firm owners must be able to appropriate at least some of their value (Ghemawat, 1991), and the efficacy of different mechanisms for ensuring appropriation by firms of the value generated is likely to vary across industries (Villalonga, 2004) and countries. Similarly, the propensity of innovation activity to be found in clusters is stronger for high-tech industries (e.g., pharmaceuticals, electronic components, semiconductors, photographic equipment and surgical and medical instruments), where new economic knowledge predominates (Audretsch and Feldman, 1996). Finally, a control for the impact of foreign subsidiaries was introduced to account for their systematically higher innovation output, as they take advantage of knowledge transfer from the parent company (Antonelli et al., 2010).

For the DS equation, the specific-to-DS variables (*see* Table 2 for a description) included in the model change as a robustness check (*see* Table 3). Given the focus on design as a source of comparative advantage and a strategic tool to "survive" in global markets (Schilling and Hill, 1998), a dummy accounting for those firms declaring the international markets as their most significant market (*competitiveness*) was inserted as an explanatory variable of the amount spent on it. The hypothesis is that export/globally-oriented firms spend more on design (see Danish Design Centre, 2003; European Commission, 2009), as design is a necessary means of product differentiation for many companies facing global competition and severe price pressure. A dummy for the implementation of advanced management techniques within the firm (*advanced management strategies*) during the period 1998-2000 was also included. This variable was included to account for the positive contribution of human resource management practices and of a firm's management skills, which are valuable and difficult assets to imitate, as an explanation of more design-oriented/innovative strategies. In other words, a decision about investing in a firm's product development process depends also on how updated the firm's managerial capabilities are: the hypothesis being that a firm undertaking activities which improve or significantly change its strategies is keener on investing in product development. In any case, controlling for the role of human resource management within a firm is necessary, according to Hertenstein and Platt (1998) who pointed out the importance of cross-functional product design teams for successful products, and that a sequential process (in contrast to an iterative process), where the new product is passed from one department to the other (e.g., R&D, design, marketing and distribution), is less successful. Furthermore, this variable is important as it indirectly enters the INNO equation through the DS* latent variable (*latentstar de*). As designing requires several disciplines and develops strong coordination competencies, the return on innovation sales for this kind of investment is likely to be affected by the firm's management view: a lack of awareness amongst top management and competing priorities (R&D, marketing, etc). In fact, design is sometimes used only at the final styling stage of product development, despite the potential of design and "design thinking" to be used strategically (INNOGRIPS, 2008). Finally, as suggested by the literature, a series of variables (which change according to the model considered) were inserted to account for the use of strategic protection during the period 1998-2000 by the firm. This is because it is generally thought (Cassiman and Veuglers, 2002) that the ability to prevent valuable information from reaching other firms using formal methods (e.g., trademarks or design pattern registration) and strategic methods (e.g., secrecy or design complexity) increases the probability of a firm investing in innovation input (in the CIS questionnaire: *proreg*, *protim*, *prosec*, *prodes*, *proreg*; see Table 2 for a description). In addition, inserting these variables is also justified in view of the use of design as a technique to differentiate a product: it could be the case that the less a firm is able to protect its innovation, the higher its propensity to enhance its performance using non-technological innovations. Consequently, there are no expectations on the sign of the last set of dummies. However, for the dummy inserted as an explanatory variable in model 4 accounting for the role of users as a source of information (*sclizeroone*), the more user-driven firms are expected to invest more in designing their innovative products.

Among the variables which are specific to the equation RD, besides the predicted values of design expenditures (DS*), there is a dummy accounting for financial support for innovation activities from local or regional authorities, central government or the European Union (*funding*; Bérubé and Mohnen, 2007; Busom, 2000; David et al., 2000), as well as a dummy for those firms who declared a lack of appropriate financial resources as a factor hampering their innovation activities (*lack of financial resources*). Those firms which constantly invest in R&D (*R&Dconstant*) and those which applied for at least one patent (*patent activity*) during the period 1998-2000 were also controlled for. To check for robustness, a dummy for innovation cooperation with other enterprises or institutions over the same period (*cooperating firm*; Coen and Levinthal 1990)[16] was used alternatively. These last three dummies were expected to be positive in the *RD-pers* equation as they were inserted to control for continuous and established R&D. These firms with intensive and continuous

[16] Many authors find that cooperating firms spend more on R&D (e.g., see Mairesse and Mohnen, 2010).

innovation were expected to develop a higher "absorptive capacity", implying that they are better at benefiting from knowledge spillovers (Paananen and Kleinknecht, 2010), and systematically have higher qualified personnel dedicated to R&D. Furthermore, the theoretical literature suggests that, for the *cooperating firms* and *patent activity* controls, the less the appropriability of innovation process results the lower the probability a firm will invest and, at the same time, the higher the incentives from cooperative R&D agreements. More specifically, when spillovers are above a critical level, cooperating firms will spend more on R&D and are increasingly more profitable compared to non-cooperating enterprises (d'Aspremont and Jacquemin, 1988; Kamien et al., 1992; De Bondt, 1997; Cassiman and Veuglers, 2002). Therefore, both *co* and *paap* are expected to be positive in the RD.

In the basic *INNO* equation (without interaction terms), the two latent variables DS* and RD* were included as "sources" of competitive advantage. Also included were a dummy for firms that introduced significant changes in their marketing concepts and strategies (*new marketing concepts/strategies*) during 1998-2000 and a dummy for those firms that introduced significant changes in the aesthetic appearance of a product (pure product design; *new design, aesthetic changes*). The dummy *new marketing concepts/strategies* was included to account for the complementary nature of marketing, design and R&D, while the dummy *new design, aesthetic changes* was included for the above reason and for completeness, as the definition of design used in this study does not include pure changes in the aesthetic appearance of a product. In other words, it does not control for those firms that use a pure product's visual appearance as a means of differentiation, while design innovation should be considered as an aspect of product innovation (see Tolke et al., 2009), as both technical and design innovation are important drivers of firms' sales, as argued in section 2. This is particularly true in many mature markets, where new products have very similar technological features and compete on a product's visual appearance (Hertenstein et al., 2005; Pearson et al., 2007; Talke et al., 2009; Veryzer, 1995). Although there are authors who argue that innovative design could not be easily accepted by consumers (e.g. Schoormans and Robben, 1997), as most products are tested before their launch (Tolke et al., 2009), design is expected to positively correlate with innovation sales. Design helps to convey the abstract features of a product to the user, and "makes a contribution to innovation that produces a more rounded-out effect, meeting the needs of the user" (Walsh, 1996, p. 513). In line with this argument, a firm using its clients as its main source of information is likely to be closer to its needs, and consequently sell more innovative products (Engel et al., 2005). Consequently, a dummy was introduced to control for those firms that identified their customers as a main source of information for suggesting new innovation projects or contributing to the implementation of existing projects (*clients as source of information*), giving the project team access to new information (Brown and Eisenhardt, 1995). Moreover, for a new product to achieve significant success, it must meet customer requirements (Schilling and Hill, 1998).

Finally, to address whether, *ceteris paribus,* design expenditures and R&D expenditures have the same impact on innovation in small and medium-sized enterprises and large firms, two interaction terms were inserted for the two latent variables *latentstar de** and *latentstar rdtot** (latent design in SME: *design sme*; latent design in big firms: *design big*; latent R&D personnel in SME: *lnred sme*; and latent R&D in big firms: *lnred big*), as well as a dummy to identify small and medium-sized enterprises (*sme*). To assess whether the returns on design and R&D investment differ according to the firm size, an Ftest on linear restriction on coefficients was performed. In line with previous empirical literature, for R&D investment a positive production scale is expected (i.e., higher R&D returns for larger firms). On the other side, returns to design expenditures are not expected to be affected by the production scale, as the structural nature of product development processes are likely to give a firm an advantage irrespective of its size.

# 4 Descriptive and econometric analysis

This section describes the results obtained from estimating the aforementioned system of equations. Tables 4 to 7 report the results of the estimation for the four models considered in this study, as well as the estimated robustness check (each model has a slightly different specification; see Table 3) for both new-to-the-firm and new-to-the-market products. In each table, column *c* has the results from estimating the baseline model (without interaction terms, for new-to-the-firm and new-to-the-market products, respectively) and column *d* reports the results obtained through bootstrap re-sampling, column *e* reports the results obtained when the interaction terms are introduced to control for differences in the returns on design and R&D investment for SMEs and large firms, and column *f* the same estimates obtained through bootstrap re-sampling. The results were robust and confirmed for both new-to-the-firm and new-to-the-market products across the different equation system specifications (as far as the sign of the variables and their significance are concerned). Therefore, for the sake of simplicity, comments are restricted to the empirical evidence obtained for the DS and R&D equations by estimating *model 1* for new-to-the-firm products. For the innovation sales equation (the third of the structural system), the focus is more on its augmented version (i.e., with the interaction terms, column *d*) and the range of estimates obtained from the four systems of equations. The main findings are the marginal effects of the latent variables of interest (*design sme**; *design big**; *R&D sme**; *R&D big**) on innovation sales (INNO equation), and these are reported and summarised in Table 8 for all four different systems of equations (only the direct effect of design is reported). It is worth noting that, given the cross-sectional structure of the CIS, the causality links between variables are generally intended to be "weak links"; and the objective of the following analysis is not to test cause-effect relationships, but to assess the significance and intensity of the correlation between the main variables of interest. Finally, it is worth reminding that, while continuous variable marginal effects can be interpreted as elasticities, for dummy variables they represent changes in the predicted probabilities for a unit change from a status of 0 to a status of 1.

For both new-to-the-firm and new-to-the-market products in the DS equation, the empirical evidence suggests that the size of the firm and whether it belongs to a group do not influence design expenditure, confirming their potentiality for SMEs; this finding is different to previous empirical studies (e.g., see Design Council, 2007). At the same time, results corroborate the crucial role of the “competition” driver (*competitiveness*): on average a firm competing in international markets invests slightly more than average (1.27%) in design than a firm operating in national markets. In addition, attitudes to the use of design are not concentrated in particular sectors. This is in line with previous works (e.g., see Tether, 2005), which stated that design investment is more distributed across sectors, unlike R&D investment which tends to be concentrated in large firms in some high-tech sectors,. In addition, all the covariates included to account for the implementation of strategic protection tools by the firm (*existence of valid patents* and *registration of design patterns*) are significant and are positive in the DS equation. This is also the case for the alternative controls included in models 2 to 4: having protected inventions or innovations developed internally during the period 1998-2000 with formal methods such as trademarks or with more strategic-oriented ones such as a complex design and/or secrecy, always has a positive influence on design expenditure. Closeness to user needs (*clients as a source of information*) is found to be significant and positive, suggesting that if a firm uses its clients as a source of information, it is likely to spend more on design. This is not surprising, as user needs, aspirations and abilities are the starting point and focus of design activities, which take into account all the user’s technical needs. This is because potential consumers may dislike a product for psychological reasons or because it lowers their efficiency in performing a task, thus, hampering the commercial success of a product.

For R&D investment decisions by a firm, results confirm the positive and significant impact of design expenditures, of receiving public funding (from local/regional authorities, central government and/or the European Union; *funding*) during the period 1998-2000, of a firm's size (Lichtenberg and Siegel, 1991; Cohen and Klepper, 1996) and of belonging to a group, which is in line with the previous extensive literature. The empirical findings suggest that smaller enterprises, with limited financial resources and less managerial infrastructures, tend to rely less than large firms on costly research and development investment for innovation activities (Jones and Craven, 2000; Lim and Klobas, 2000; Nootboom, 1993). Not surprisingly, an indicator for a firm's degree of involvement in R&D, constantly investing in R&D (*R&Dconstant*) and collaborating on innovation activities (*cooperating firm*) with other enterprises or institutions during the years 1998-2000 are positive in the equation. In particular, a firm investing constantly in R&D spends 0.91% more than a firm that does not, and firms that had at least one cooperation agreement with any type of partner during the years 1998-2000 invested 0.48% more in R&D than their competitors not following the same strategy. These last two variables are important, as they were inserted to compensate for the lack of information in the CIS on the amount of R&D in a firm, which is supposed to be the relevant driver for innovation performance given an R&D investment pay-back period. Finally, the amount spent on R&D increases with a firm's size, which is in line with previous studies and is generally interpreted as a sign of a cost spread advantage[17]. In fact, an increase of 1% in size leads to an increase of 0.65% in R&D expenditure. Therefore, the larger the firm, the greater the output over which it can apply the fruits of its R&D or over which it can average the cost of these investments (Nelson and Winter, 1978, 1982). Results for the industry dummies were in line with what may be expected given their R&D intensity: a firm belonging to a high intensity R&D manufacturing sector spends more on R&D than a medium-low or low-tech services firm. Also, market services and high tech services were positive and significant in the equation, while low tech services were not.

Estimates of the impact of R&D and design investment on a firm's innovation performance corroborate the hypothesis that technological activities *and* project definition (R&D phase management and product development intensity) are critical steps in the new product development process, in line with Talke et al. (2009). All in all, as far as the baseline INNO equation is concerned (with no SME interaction terms), the empirical evidence strongly confirms design as a significant creative input to technological innovation beyond R&D, suggesting that if this expenditure is not accounted for by confining attention to R&D

[17] However, this cost spread advantage is not due to a large size *per se* (Cohen and Klepper, 1996, p. 926), but is the consequence of two different conditions. First of all, firms may exploit their innovations predominantly through their own output rather than by selling them in disembodied forms (larger firms in terms of output better exploit their R&D). Secondly, firms do not intend to grow rapidly due to innovation and, consequently, the output over which they expect to apply their R&D is closely related to their output when

investment, a significant part of the picture is missed. As these two key variables enter the INNO equation as latent ones, it must also be stressed that they capture not only the firm's single expenditure efforts in design and R&D, but also the externalities associated with these two kinds of expenditures. Design expenditures have a direct return on innovative sales that ranges from 0.34% to 0.50% (depending on which of the 4 models is considered and considering the sum of the direct and indirect - through the R&D equation - effects), while those to R&D are between 0.67% and 0.88%. Therefore, establishing a link between the "voice of the customer in terms of perceived needs" (Urban and Hauser, 1993) and how a product is designed and produced is crucial. If there are many aspects to product innovation, the impact of introducing changes in the product's appearance is significant and positive.

These results are also confirmed when the interaction terms for SMEs and large firms are inserted in the INNO equation for all four models estimated (see Table 8 for a summary of the results). Overall, the impact of product design (*new design, aesthetic changes*) is always positive and significant. As far as the range of variation of the impact of the latent design expenditures (*design sme**) is concerned, when the total impact is considered we obtain a range of returns for the four models of 0.33%-0.50% for a SME and 0.34%-0.51% for large firms (*design big**). As shown by the Ftest, the slight differences in the returns to design expenditures observed between SME and large firms are not statistically significant. For the elasticity of innovation sales to R&D (*R&D_sme** and *R&D _big**), the range is 0.56%-0.79% for SMEs and 0.82%-1.12% for large firms and, differently from the previous case, this time the Ftest on linear restrictions suggested that these differences are statistically significant. This implies that the ability of the firm to capture knowledge externalities is positively correlated with the scale of production. In line with the emerging economic literature on complementarities in innovation (Guidetti and Mazzanti, 2007) and with other empirical studies dedicated to the innovation impact of human capital (Ciriaci, 2011) and marketing expenditure (Garcia, 2011), these results also support the view that what really matters for innovation is the degree to which these intangibles are used within the production and innovation process, and how this is affected by the different skills, complementary assets and routines available within the firm (Leonard-Barton, 1992).

The finding that returns to design expenditures are not affected by the production scale supports the idea that this type of investments are structural. To some extent, this is inherent in the definition of this category in the CIS, and very much in line with the rational approach to NPD (Myers and Marquis, 1969). It implies that proactive product development can influence the innovation success of a firm by creating a competitive advantage that enhances

conducting the R&D. Therefore, these two conditions together mean that the larger a firm's output when a product's uniqueness (Brown and Eisenhardt, 1995), irrespective of a fim's size. In fact, it was found that the amount of design expenditures is not affected by the production scale (DS equation), which suggests that firms may not need to spread this cost over a larger production scale to decrease their average costs, as with R&D investment. Also, the production scale does not even influence the returns to them, which suggests that the self-reinforcing process, typical of R&D and innovation in large firms, does not operate for design expenditures: large firms and SMEs obtain the same return/competitive advantage due to design. These results highlight the potential of this expenditure as a far less costly alternative (or complement) to R&D investment in SMEs. As a further robustness check I also controlled for differential returns to pure aesthetic changes in a firm's product appearance, and also in this case, the elasticities of innovative sales do not differ between SME and large firms[18]. As it will be discussed in the conclusions to this study, these results suggest that policies attempting to realise the innovative potential of firms, especially SMEs, need to recognise the variety of ways in which firms innovate and the importance of key factors such as design, intended both as the process of product development and as the 'look' of products.

Furthermore, both in the baseline model (without the interaction terms) and in the augmented one (with interaction terms), the dummy inserted to control for significant changes in a firm's marketing concepts and strategies during the years 1998-2000 turned out to be a significant and positive determinant of the firm's innovation performance. This result is in line with Garcia (2011) who analysed the same dataset used in this study. Focusing on the impact of marketing expenditure for launching new products, he found its return on a firm's innovation performance was almost double that for R&D. Moreover, in line with that suggested, e.g., in Tolke et al. (2009), the empirical findings confirm that pure design innovation is a significant explanatory variable of the innovation sales of European firms, thus emphasizing the importance of overall product innovation and its different aspects. The objective of technological innovation is to sell the production process output profitably, but this can be achieved only if customers are willing to buy it. In turn, they may be willing to buy it because of its price competitiveness and/or its quality, to which both R&D and technical and product design contribute[19].

These results are also confirmed for breakthrough innovation, for both new-to-the-firm and new-to-the-market products. Though we cannot compare the elasticities obtained running the model for innovation "new-to-the-firm" and "new-to-the-market" sales, as differences in

R&D are conducted, the greater the incentive to invest in R&D.

[18] Results are available on request.

results may be due to sample selection, it is crucial to observe the robustness of results obtained, and that design investment (defined as both a process and an outcome) is positively correlated with incremental and breakthrough innovation.

# 5 Conclusions & policy implications

Using a large dataset of European firms, this study was aimed at empirically investigating to what extent design expenditures - defined as the procedures, choice of elements and technical preparation to implement a new product - contribute to the success of an innovation acting as a complement to R&D and to pure product design (defined as changes in the visual appearance of the product).

The empirical evidence presented in this study supports the view of design as a driver of user-centred innovation advanced by the European Commission (2009) and confirms it is complementary to R&D: spending on product development procedures, R&D and changes in product appearance are all positively correlated with innovation sales. In particular, an increase of 1% in a firm's design expenditures (i.e. in the product development process) increases innovation sales by between 0.34% to 0.50% (depending on which of the 4 models is considered), while the same increase in R&D investment boosts innovation sales by between 0.67% and 0.88%. Therefore, the empirical findings support a multi-aspect view of product innovation and complementarity with technological and non-technological innovation.

Interestingly, while investing in design shows similar returns in terms of innovation output in small and medium-sized enterprises and large firms, this is not the case for R&D investments. In fact, the elasticity range of innovation sales for R&D is 0.56%-0.79% for SMEs and 0.82%-1.12% for large firms. *Ceteris paribus*, the same amount of investment in R&D shows significantly higher than average returns for large firms, which can also be interpreted as a sign that a firm's ability to capture R&D knowledge externalities is significantly higher in large firms. This is not the case for design investment, which has the potential to be much more widely used in SMEs as it is less capital intensive and has the same returns irrespective of a firm's production scale. Furthermore, while R&D behaviour varies significantly with the sector, design turned out to be widely used as an innovation tool for both manufacturing and service firms and in low, medium and high tech sectors. These findings support the EC strategy of enhancing non-R&D innovation in SMEs and in low-tech

[19] In line with this result, the dummy *actaes* inserted in model 2 to account for the introduction of aesthetic improvements in the appearance of a firm's products is significant and positive. A firm that introduced these pure design improvements sold 1.3% more than a firm that did not.

industries where an in-house R&D department may seem too big an investment. Therefore, R&D should be encouraged, as should innovation activities that are close to the market and that have lower capital requirements (European Commission, 2009).

This study raises an interesting question concerning the degree to which the impact of design both as product development process and a product's aesthetic appearance has been almost ignored in studies on the effects of different corporate inputs, such as R&D and marketing, on a firm's performance. Behind every product image lie numerous design decisions about appearance, user-friendliness, ease of manufacture, ergonomics and efficient use of materials, and often with the incorporation of innovative technologies or materials. Integrating the functions of R&D and design leads to more successful innovation performance, as demonstrated by the present study. It is time for industrial design to be factored in with other intangible assets as non-technological drivers of corporate innovation performance, as product innovation is a multi-dimensional concept which is not limited to the purely technological dimension. The policy conclusions are clear: design is a less costly alternative to R&D for many SMEs and a policy of supporting design should be considered, as this might be a more cost-efficient support strategy. On the one side, design as product development opens the innovation process and constitutes the industrial architecture within which innovation takes place. On the other side, design as aesthetic appearance 'closes the innovation loop' (European Commission, 2010) from initial research to commercially viable innovations and, as such, has the potential to complement existing innovation and research policy and to widen the target audience for European innovation policy to mature markets, sectors and regions characterised by non-technological activities and large SME populations, for which investment in technological research may be unfeasible or unsuitable.

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# Annexes

## Tables

Table 1. European firms that have engaged in design activities in 2000

| | | Did your enterprise engage in training activities: yes | Did your enterprise engage in training activities: no | |
|---|---|---|---|---|
| Did your enterprise engage in marketing activities in 2000? | yes | 5,134 | 1,052 | 6,186 |
| | no | 1,487 | 1,445 | 2,932 |
| Total | | 6,621 | 2,497 | 9,118 |

Source: Author's elaboration on CIS data, Eurostat.

Table 2. Descriptive statistics

| Variable | Description | Observations | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|---|
| | | | | | | |
| *Design* | Amount of investment in design direct at the introduction of new products (log) | 39761 | .1959359 | 1.183347 | 0 | 15.18381 |
| *R&D* | Amount of investment in R&D (external and internal; log) | 18188 | 11.75285 | 2.397024 | 1.088628 | 21.99583 |
| *Innosales* | Amount of innovative sales, i.e. new to the firm products (log) | 62933 | 5.455105 | 7.035876 | 0 | 24.69164 |
| *Competitiveness* | Dummy variable taking up the value 1 if the firm declares that its most significant market is the international one, zero otherwise. | 87499 | .2425742 | .4286421 | 0 | 1 |
| *Employees* | Number of employees (log) | 87344 | 3.958507 | 1.320868 | .6931472 | 12.68913 |
| *Group* | Dummy variable taking up the value 1 if the firm belongs to a group, zero otherwise. | 86839 | .3004526 | .4584575 | 0 | 1 |
| *Funding* | Dummy variable taking up the value 1 if the firm received public financial support for innovation activities, zero otherwise. | 33821 | .2846161 | .4512381 | 0 | 1 |
| *R&Dconstant* | Dummy variable taking up the value 1 if the firm constantly invest in R&D, zero otherwise. | 20062 | .5834912 | .4929922 | 0 | 1 |
| *SME* | Dummy variable taking up the value 1 if the firm has a number of employees<250 and an amount of | 79845 | .9228881 | .2667706 | 0 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | sales <=50,000,000, zero otherwise. | | | | | |
| *Lack of source of finance* | Dummy variable taking up the value 1 if the firm declared a lack of appropriate sources of financing as a hampering factor, zero otherwise. | 70302 | .4793889 | .4995786 | 0 | 1 |
| *Cooperating firm* | Dummy variable taking up the value 1 if the firm has cooperated on innovation activities with other enterprises and/or Institutions during the period 1998-2000, zero otherwise. | 34409 | .2902148 | .453868 | 0 | 1 |
| *Clients as source of information* | Dummy variable taking up the value 1 if the firm declared clients as the main source of information needed for suggesting new innovation projects during the period 1998-2000, zero otherwise. | 33808 | .7198888 | .44906 | 0 | 1 |
| *Advanced management strategies* | Dummy variable taking up the value 1 if the firm implemented advanced management techniques during the period 1998-2000, zero otherwise. | 85882 | .2445565 | .4298264 | 0 | 1 |
| *New organizational structures* | Dummy variable taking up the value 1 if the firm implemented new or significantly changed organizational structures during the period 1998-2000, zero otherwise. | 85880 | .3150442 | .4645362 | 0 | 1 |
| *New marketing concepts/strategies* | Dummy variable taking up the value 1 if the firm significantly changed its marketing concepts/strategies during the period 1998-2000, zero otherwise. | 85883 | .2246195 | .417334 | 0 | 1 |
| *Aesthetic changes* | Dummy variable taking up the value 1 if the firm significantly changed its | 85863 | .2448435 | .4299969 | 0 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | product's appearance/design during the period 1998-2000, zero otherwise. | | | | | |
| *Patent activity* | Dummy variable taking up the value 1 if the firm applied for at least one patent over the period 1998-2000, zero otherwise. | 85726 | .083032 | .2759322 | 0 | 1 |
| *Existence of valid patents* | Dummy variable taking up the value 1 if the firm have valid patents at the end of 2000, zero otherwise. | 82086 | .1075701 | .3098386 | 0 | 1 |
| *Registration of design patterns* | Dummy variable taking up the value 1 if the firm has registered design patterns over the years 1998-2000, zero otherwise. | 85567 | .0632954 | .243495 | 0 | 1 |
| *Secrecy* | Dummy variable taking up the value 1 if the firm has protected its innovations choosing secrecy as strategic method over the years 1998-2000, zero otherwise. | 85150 | .1283265 | .3344549 | 0 | 1 |
| *Trademarks* | Dummy variable taking up the value 1 if the firm has protected with trademarks over the years 1998-2000, zero otherwise. | 85123 | .1543884 | .3613227 | 0 | 1 |
| *Complexity of design* | Dummy variable taking up the value 1 if the firm has protected its innovations choosing design complexity as strategic method over the years 1998-2000, zero otherwise. | 84236 | .0859134 | .2802378 | 0 | 1 |
| *Lack of qualified personnel* | Dummy variable taking up the value 1 if the firm declared a lack of qualified personnel as a hampering factor, zero otherwise. | 70220 | .4313016 | .4952616 | 0 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Lack of information on markets* | Dummy variable taking up the value 1 if the firm declared a lack of information on markets as a hampering factor, zero otherwise. | 70302 | .4793889 | .4995786 | 0 | 1 |
| Industry dummies (2 digit level) | | | | | | |
| Manufacture | | | | | | |
| *High tech* | NACE 30+32+33 | 87499 | .0305489 | .1720931 | 0 | 1 |
| *Medium high tech* | NACE 24+29+31+34+35 | 87499 | .1325158 | .3390526 | 0 | 1 |
| *Medium low tech* | NACE 23+25+26+27+28 | 87499 | .1399902 | .3469788 | 0 | 1 |
| *Low tech* | NACE 15+16+17+18+19+20+21+22+36+37 | 87499 | .3235008 | .4678147 | 0 | 1 |
| *Electricity* | NACE 40+41 | 87499 | .0202745 | .1409386 | 0 | 1 |
| Services | | | | | | |
| *Market service low* | NACE 51+60+63 | 87499 | .2095338 | .4069782 | 0 | 1 |
| *Financial services* | NACE 65+66+67 | 87499 | .0370519 | .18889 | 0 | 1 |
| *High tech services* | NACE 64+72+73 | 87499 | .0424919 | .2017097 | 0 | 1 |
| *Low tech services* | NACE 50+60+63 | 87499 | .0499663 | .2178766 | 0 | 1 |
| 23 Country dummies (NUTS 2 level) | Belgium, Bulgaria, Check Republic, Germany, Denmark, Estonia, Finland, France, Greece, Hungary, Island, Italy, Latvia, Lithuania, Luxemburg, Netherland, Norway, Portugal, Romania, Slovenia, Slovakia, Spain and Sweden. | | | | | |

**Table 3. The covariates included in the 3 equations of the 4 estimated models.**

| | MODEL 1 | | | MODEL 2 | | | MODEL 3 | | | MODEL 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DS | R&D | INNO | DS | R&D | INNO | DS | R&D | INNO | DS | R&D | INNO |
| Size | x | x | x | x | x | x | x | x | x | x | x | x |
| Group | x | x | x | x | x | x | x | x | x | x | x | x |
| industry dummies | x | x | x | x | x | x | x | x | x | x | x | x |
| country dummies | x | x | x | x | x | x | x | x | x | x | x | x |
| | | | | | | | | | | | | |
| Clients as source of information | x | | x | x | | x | x | | x | x | | x |
| Advanced management strategies | x | | | x | | | x | | | x | | |
| New marketing concepts/strategies | | | x | | | x | | | | | | x |
| New design (aesthetic changes) | | | x | | | x | | | x | | | |
| Competitiveness | x | | | x | | | x | | | x | | |
| Lack of financial resources | | x | | | x | | | x | | x | x | |
| Lack of information on markets | | | | | | | | | | x | | |
| Funding | | | | | x | | | x | | | x | |
| Patent activity | | | | x | x | | x | x | | | | |
| Existence of valid patents | x | | | | | | | | | x | | |
| Secrecy | | | | x | | | | | | | | |
| Registration of design patterns | x | | | | | | | | | | | x |
| Complexity of design | | | | | | | | | | | | x |
| Trademarks | | | | | | | x | | | | | |
| Cooperating firm | | x | | | | x | | | x | | x | |
| RDconstant | | x | | | x | | | x | | | x | |

Table. 4 Tobit estimation results, new to the firm and new to the market products (without and with bootstrapped std errors). Model 1

| | Design eq | R&D eq | INNO equation: New-to-the firm products | | | | INNO equation: New-to-the market products | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | d | e | f | c | d | e | f |
| VARIABLES | | | No interactions model | No interactions model Bootstrapped std errors | SME and Large firms' interactions | SME and Large firms' interactions Bootstrapped std errors | No interactions model | No interactions model Bootstrapped std errors | SME and Large firms' interactions | SME and Large firms' interactions Bootstrapped std errors |
| latentstar_design | | 0.0903*** | 0.263*** | 0.263*** | | | 0.579*** | 0.579*** | | |
| | | (0.00721) | (0.0371) | (0.0409) | | | (0.0744) | (0.0853) | | |
| latentstar_R&D | | | 0.883*** | 0.883*** | | | 2.284*** | 2.284*** | | |
| | | | (0.101) | (0.121) | | | (0.204) | (0.226) | | |
| design_sme* | | | | | 0.254*** | 0.254*** | | | 0.569*** | 0.569*** |
| | | | | | (0.0406) | (0.0366) | | | (0.0814) | (0.0784) |
| design_big* | | | | | 0.264*** | 0.264*** | | | 0.625*** | 0.625*** |
| | | | | | (0.0443) | (0.0387) | | | (0.0889) | (0.0810) |
| R&D_sme* | | | | | 0.795*** | 0.795*** | | | 2.115*** | 2.115*** |
| | | | | | (0.107) | (0.0866) | | | (0.216) | (0.207) |
| R&D _big* | | | | | 1.121*** | 1.121*** | | | 2.918*** | 2.918*** |
| | | | | | (0.134) | (0.145) | | | (0.272) | (0.329) |
| sme | | | | | 3.146** | 3.146** | | | 8.671*** | 8.671*** |
| | | | | | (1.317) | (1.456) | | | (2.701) | (2.726) |
| Adv. management strategies | 0.637* | | | | | | | | | |
| | (0.356) | | | | | | | | | |
| Competitiveness | 1.034*** | | | | | | | | | |
| | (0.379) | | | | | | | | | |
| funding | | 0.521*** | | | | | | | | |
| | | (0.0290) | | | | | | | | |
| R&Dconstant | | 0.905*** | | | | | | | | |
| | | (0.0298) | | | | | | | | |
| Lack of financial resources | | -0.0270 | | | | | | | | |
| | | (0.0276) | | | | | | | | |
| Cooperating firm | | 0.325*** | 0.194* | 0.194* | 0.136 | 0.136 | 0.827*** | 0.827*** | 0.855*** | 0.855*** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | (0.0287) | (0.115) | (0.108) | (0.124) | (0.117) | (0.233) | (0.256) | (0.249) | (0.236) |
| New design (aesthetic changes) | | | 1.261*** | 1.261*** | 1.278*** | 1.278*** | 2.310*** | 2.310*** | 2.424*** | 2.424*** |
| | | | (0.104) | (0.115) | (0.111) | (0.120) | (0.209) | (0.188) | (0.223) | (0.192) |
| New marketing concepts/strategies | | | 0.662*** | 0.662*** | 0.638*** | 0.638*** | 2.061*** | 2.061*** | 2.029*** | 2.029*** |
| | | | (0.102) | (0.110) | (0.109) | (0.104) | (0.205) | (0.226) | (0.219) | (0.179) |
| Clients as a source of information | 2.718*** | | 0.703*** | 0.703*** | 0.661*** | 0.661*** | 0.523 | 0.523 | 0.460 | 0.460 |
| | (0.384) | | (0.161) | (0.185) | (0.170) | (0.176) | (0.324) | (0.383) | (0.343) | (0.354) |
| Existence of valid patents | 1.204** | | | | | | | | | |
| | (0.480) | | | | | | | | | |
| Registration of design patterns | 2.567*** | | | | | | | | | |
| | (0.542) | | | | | | | | | |
| lnemp | 0.0188 | 0.661*** | 0.0853 | 0.0853 | -0.0248 | -0.0248 | -1.333*** | -1.333*** | -1.506*** | -1.506*** |
| | (0.141) | (0.0103) | (0.0824) | (0.0962) | (0.0977) | (0.0870) | (0.166) | (0.168) | (0.197) | (0.189) |
| group | -0.489 | 0.284*** | 0.0996 | 0.0996 | 0.0895 | 0.0895 | 0.206 | 0.206 | 0.245 | 0.245 |
| | (0.408) | (0.0298) | (0.116) | (0.0985) | (0.125) | (0.138) | (0.232) | (0.207) | (0.251) | (0.230) |
| High tech | 0.747 | 0.783*** | 2.650*** | 2.650*** | 2.276*** | 2.276** | 3.768*** | 3.768** | 2.718* | 2.718* |
| | (1.584) | (0.179) | (0.694) | (0.861) | (0.743) | (1.014) | (1.382) | (1.593) | (1.479) | (1.495) |
| Medium high tech | 0.204 | 0.433** | 2.732*** | 2.732*** | 2.357*** | 2.357** | 3.852*** | 3.852** | 2.907** | 2.907** |
| | (1.456) | (0.174) | (0.670) | (0.794) | (0.718) | (1.004) | (1.334) | (1.537) | (1.431) | (1.384) |
| Medium low tech | 0.503 | -0.125 | 2.521*** | 2.521*** | 2.147*** | 2.147** | 3.929*** | 3.929** | 3.136** | 3.136** |
| | (1.451) | (0.175) | (0.669) | (0.814) | (0.718) | (1.021) | (1.334) | (1.562) | (1.430) | (1.303) |
| Low tech | 0.113 | -0.297* | 2.555*** | 2.555*** | 2.113*** | 2.113** | 4.642*** | 4.642*** | 3.541** | 3.541*** |
| | (1.431) | (0.174) | (0.666) | (0.823) | (0.714) | (1.030) | (1.327) | (1.592) | (1.424) | (1.299) |
| Electricity | -0.654 | 0.251 | -1.195 | -1.195 | -2.057** | -2.057* | -2.385 | -2.385 | -3.483** | -3.483** |
| | (1.882) | (0.205) | (0.794) | (1.048) | (0.854) | (1.240) | (1.594) | (1.791) | (1.719) | (1.689) |
| Market service low | -2.309 | 0.367** | 3.040*** | 3.040*** | 2.632*** | 2.632*** | 4.916*** | 4.916*** | 4.076*** | 4.076*** |
| | (1.491) | (0.179) | (0.683) | (0.764) | (0.732) | (1.012) | (1.361) | (1.616) | (1.460) | (1.323) |
| Financial services | 0.500 | 0.604*** | 3.215*** | 3.215*** | 2.790*** | 2.790*** | 2.699* | 2.699* | 1.606 | 1.606 |
| | (1.667) | (0.183) | (0.699) | (0.845) | (0.752) | (1.050) | (1.398) | (1.526) | (1.504) | (1.427) |
| High tech services | 1.429 | 0.385** | 1.281* | 1.281* | 0.925 | 0.925 | 1.724 | 1.724 | 0.489 | 0.489 |
| | (1.623) | (0.182) | (0.701) | (0.773) | (0.748) | (1.010) | (1.399) | (1.640) | (1.494) | (1.589) |
| Low tech services | -1.705 | 1.414*** | 2.303*** | 2.303*** | 2.047*** | 2.047* | 3.967*** | 3.967** | 3.047** | 3.047** |
| | (1.596) | (0.177) | (0.704) | (0.824) | (0.754) | (1.044) | (1.403) | (1.633) | (1.503) | (1.540) |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Austria | -11.73*** | 8.700*** | 0.792 | 0.792 | -0.851 | -0.851 | -21.01*** | -21.01*** | -27.26*** | -27.26*** |
| | (1.884) | (0.225) | (1.278) | (1.679) | (1.804) | (1.928) | (2.565) | (3.003) | (3.660) | (3.971) |
| Belgium | -14.13*** | 8.774*** | -0.982 | -0.982 | -2.499 | -2.499 | -19.72*** | -19.72*** | -25.12*** | -25.12*** |
| | (1.882) | (0.211) | (1.298) | (1.658) | (1.826) | (2.069) | (2.620) | (3.253) | (3.715) | (3.759) |
| Bulgaria | -12.89*** | 7.035*** | 2.500** | 2.500* | 0.876 | 0.876 | -12.57*** | -12.57*** | -18.07*** | -18.07*** |
| | (1.621) | (0.226) | (1.132) | (1.458) | (1.712) | (1.856) | (2.269) | (2.747) | (3.477) | (3.623) |
| Czech republic | -23.65*** | 7.860*** | 2.992** | 2.992* | 1.294 | 1.294 | -9.516*** | -9.516*** | -14.66*** | -14.66*** |
| | (1.754) | (0.247) | (1.419) | (1.769) | (1.920) | (1.881) | (2.852) | (3.443) | (3.893) | (4.138) |
| Denmark | -13.27*** | 8.415*** | -1.048 | -1.048 | -2.686 | -2.686 | -17.88*** | -17.88*** | -23.45*** | -23.45*** |
| | (1.712) | (0.203) | (1.245) | (1.610) | (1.779) | (1.984) | (2.505) | (3.013) | (3.615) | (3.834) |
| Estonia | -13.53*** | 6.560*** | 2.703** | 2.703* | 1.100 | 1.100 | -16.48*** | -16.48*** | -22.32*** | -22.32*** |
| | (1.698) | (0.208) | (1.107) | (1.441) | (1.699) | (1.842) | (2.220) | (2.689) | (3.450) | (3.636) |
| Spain | -16.69*** | 8.851*** | 2.171 | 2.171 | 0.619 | 0.619 | -17.25*** | -17.25*** | -22.36*** | -22.36*** |
| | (1.617) | (0.214) | (1.340) | (1.725) | (1.858) | (1.979) | (2.691) | (3.280) | (3.768) | (3.936) |
| Finland | -20.85*** | 9.196*** | 0.440 | 0.440 | -1.040 | -1.040 | -12.46*** | -12.46*** | -17.76*** | -17.76*** |
| | (1.902) | (0.232) | (1.455) | (1.860) | (1.956) | (1.902) | (2.925) | (3.459) | (3.967) | (4.099) |
| France | -21.76*** | 9.110*** | 2.538* | 2.538 | 0.832 | 0.832 | -14.72*** | -14.72*** | -20.33*** | -20.33*** |
| | (1.832) | (0.252) | (1.482) | (1.877) | (1.979) | (2.084) | (2.990) | (3.577) | (4.022) | (4.142) |
| Greece | -20.74*** | 2.273*** | 6.760*** | 6.760*** | 4.596*** | 4.596*** | 1.967 | 1.967 | -4.432 | -4.432 |
| | (2.503) | (0.249) | (1.106) | (1.291) | (1.679) | (1.711) | (2.220) | (2.782) | (3.411) | (3.357) |
| Hungary | -18.25*** | 7.532*** | -0.266 | -0.266 | -1.741 | -1.741 | -16.26*** | -16.26*** | -20.63*** | -20.63*** |
| | (2.227) | (0.292) | (1.486) | (1.784) | (2.008) | (2.078) | (3.005) | (3.350) | (4.073) | (3.794) |
| Ireland | -18.51*** | 9.020*** | 2.389 | 2.389 | 0.879 | 0.879 | -18.06*** | -18.06*** | -23.29*** | -23.29*** |
| | (4.135) | (0.258) | (1.486) | (1.769) | (1.968) | (1.991) | (2.961) | (3.371) | (3.967) | (4.321) |
| Lithuania | -9.715*** | 6.050*** | -1.137 | -1.137 | -2.420 | -2.420 | -14.40*** | -14.40*** | -19.66*** | -19.66*** |
| | (1.764) | (0.202) | (1.002) | (1.355) | (1.622) | (1.881) | (2.017) | (2.427) | (3.302) | (3.346) |
| Luxemburg | -16.41*** | 8.898*** | -0.580 | -0.580 | -1.406 | -1.406 | -19.11*** | -19.11*** | -24.34*** | -24.34*** |
| | (2.947) | (0.249) | (1.420) | (1.762) | (1.919) | (2.079) | (2.879) | (3.175) | (3.913) | (4.168) |
| Latvia | -9.035*** | 6.076*** | 1.240 | 1.240 | -0.0885 | -0.0885 | -17.99*** | -17.99*** | -23.06*** | -23.06*** |
| | (1.722) | (0.317) | (1.032) | (1.295) | (1.644) | (1.833) | (2.062) | (2.453) | (3.337) | (3.388) |
| Netherlands | -25.86*** | 9.399*** | 4.490*** | 4.490** | 3.107 | 3.107 | -9.541*** | -9.541** | -14.70*** | -14.70*** |
| | (1.867) | (0.256) | (1.590) | (2.046) | (2.072) | (2.034) | (3.194) | (3.842) | (4.195) | (4.285) |
| Portugal | -17.79*** | 7.988*** | -0.249 | -0.249 | -1.888 | -1.888 | -10.96*** | -10.96*** | -16.19*** | -16.19*** |
| | (1.850) | (0.230) | (1.313) | (1.622) | (1.839) | (1.949) | (2.638) | (3.236) | (3.731) | (3.929) |
| Romania | -18.65*** | 6.581*** | 2.202* | 2.202 | 0.798 | 0.798 | -4.444* | -4.444 | -9.879*** | -9.879*** |
| | (1.771) | (0.228) | (1.233) | (1.580) | (1.781) | (1.868) | (2.473) | (3.025) | (3.611) | (3.641) |
| Sweden | -16.72*** | 9.255*** | -2.708** | -2.708 | -4.090** | -4.090** | -21.07*** | -21.07*** | -26.09*** | -26.09*** |
| | (1.820) | (0.216) | (1.368) | (1.756) | (1.886) | (2.081) | (2.757) | (3.384) | (3.832) | (4.091) |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Slovenia | -9.829*** | 7.535*** | -0.727 | -0.727 | -2.134 | -2.134 | -17.33*** | -17.33*** | -22.35*** | -22.35*** |
| | (1.894) | (0.200) | (1.147) | (1.566) | (1.708) | (1.951) | (2.310) | (2.708) | (3.475) | (3.669) |
| Slovakia | -17.85*** | 7.304*** | 3.265** | 3.265** | 1.940 | 1.940 | -12.75*** | -12.75*** | -17.31*** | -17.31*** |
| | (2.508) | (0.282) | (1.283) | (1.613) | (1.821) | (1.847) | (2.574) | (3.027) | (3.694) | (3.955) |
| Italy | -17.20*** | 8.803*** | 0.985 | 0.985 | -0.518 | -0.518 | -11.55*** | -11.55*** | -16.93*** | -16.93*** |
| | (1.595) | (0.214) | (1.339) | (1.773) | (1.856) | (1.998) | (2.691) | (3.225) | (3.765) | (3.938) |
| Constant | 10.54*** | 1.372*** | 5.407*** | 5.407*** | 5.348*** | 5.348*** | 10.52*** | 10.52*** | 10.39*** | 10.39*** |
| | (0.265) | (0.00897) | (0.0371) | (0.0631) | (0.0395) | (0.0602) | (0.0934) | (0.0763) | (0.0992) | (0.0755) |
| Observations | 15,593 | 11,690 | 13,522 | 13,522 | 11,693 | 11,693 | 14,429 | 14,429 | 12,482 | 12,482 |

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 5. Tobit estimation results, new to the firm and new to the market products. Model 2

| | Design eq | R&D eq | INNO equation: New-to-the firm products | | | | INNO equation: New-to-the-market products | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | d | e | f | c | d | e | f |
| VARIABLES | | | No interactions model | No interactions model Bootstrapped std errors | SME and Large firms' interactions | SME and Large firms' interactions Bootstrapped std errors | No interactions model | No interactions model Bootstrapped std errors | SME and Large firms' interactions | SME and Large firms' interactions Bootstrapped std errors |
| latentstar_design | | 0.0721*** | 0.324*** | 0.324*** | | | 0.628*** | 0.628*** | | |
| | | (0.00943) | (0.0491) | (0.0544) | | | (0.0997) | (0.0943) | | |
| latentstar_R&D | | | 0.780*** | 0.780*** | | | 2.264*** | 2.264*** | | |
| | | | (0.0930) | (0.0938) | | | (0.189) | (0.192) | | |
| design_sme* | | | | | 0.306*** | 0.306*** | | | 0.649*** | 0.649*** |
| | | | | | (0.0529) | (0.0538) | | | (0.108) | (0.108) |
| design_big* | | | | | 0.321*** | 0.321*** | | | 0.722*** | 0.722*** |
| | | | | | (0.0564) | (0.0631) | | | (0.115) | (0.106) |
| R&D_sme* | | | | | 0.688*** | 0.688*** | | | 2.018*** | 2.018*** |
| | | | | | (0.0987) | (0.0952) | | | (0.202) | (0.218) |
| R&D _big* | | | | | 0.954*** | 0.954*** | | | 2.711*** | 2.711*** |
| | | | | | (0.124) | (0.133) | | | (0.256) | (0.271) |
| sme | | | | | 2.394* | 2.394 | | | 7.204*** | 7.204** |
| | | | | | (1.302) | (1.469) | | | (2.696) | (2.964) |
| Adv. management strategies | 0.717* | | | | | | | | | |
| | (0.366) | | | | | | | | | |
| Competitiveness | 1.272*** | | | | | | | | | |
| | (0.391) | | | | | | | | | |
| Funding | | 0.532*** | | | | | | | | |
| | | (0.0272) | | | | | | | | |
| R&Dconstant | | 0.909*** | | | | | | | | |
| | | (0.0284) | | | | | | | | |
| Lack of financial resources | | -0.0207 | | | | | | | | |
| | | (0.0265) | | | | | | | | |
| Lack of information on markets | 0.519 | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (0.345) | | | | | | | | | |
| Cooperating firm | | | 0.478*** | 0.478*** | 0.423*** | 0.423*** | 1.527*** | 1.527*** | 1.566*** | 1.566*** |
| | | | (0.102) | (0.101) | (0.109) | (0.111) | (0.208) | (0.207) | (0.223) | (0.213) |
| New design (aesthetic changes) | | | 1.310*** | 1.310*** | 1.318*** | 1.318*** | 2.364*** | 2.364*** | 2.498*** | 2.498*** |
| | | | (0.101) | (0.0946) | (0.107) | (0.0815) | (0.205) | (0.174) | (0.218) | (0.247) |
| New marketing concepts/strategies | | | 0.585*** | 0.585*** | 0.556*** | 0.556*** | 2.025*** | 2.025*** | 1.994*** | 1.994*** |
| | | | (0.0998) | (0.0920) | (0.106) | (0.0997) | (0.202) | (0.212) | (0.216) | (0.240) |
| Clients as source of information | 2.550*** | | 0.676*** | 0.676*** | 0.672*** | 0.672*** | 0.511 | 0.511 | 0.382 | 0.382 |
| | (0.398) | | (0.178) | (0.234) | (0.188) | (0.227) | (0.363) | (0.352) | (0.385) | (0.367) |
| Patent activity | 1.585*** | 0.459*** | | | | | | | | |
| | (0.492) | (0.0345) | | | | | | | | |
| Secrecy | 0.771* | | | | | | | | | |
| | (0.400) | | | | | | | | | |
| lnemp | 0.0943 | 0.653*** | 0.127* | 0.127* | 0.0510 | 0.0510 | -1.422*** | -1.422*** | -1.519*** | -1.519*** |
| | (0.145) | (0.00997) | (0.0750) | (0.0691) | (0.0898) | (0.0838) | (0.153) | (0.150) | (0.183) | (0.201) |
| group | -0.329 | 0.284*** | 0.104 | 0.104 | 0.110 | 0.110 | 0.0948 | 0.0948 | 0.202 | 0.202 |
| | (0.414) | (0.0284) | (0.113) | (0.148) | (0.121) | (0.130) | (0.230) | (0.257) | (0.247) | (0.286) |
| High tech | 1.777 | 0.486*** | 2.514*** | 2.514*** | 2.119*** | 2.119*** | 3.234*** | 3.234*** | 2.181* | 2.181 |
| | (1.628) | (0.154) | (0.601) | (0.938) | (0.644) | (0.713) | (1.233) | (1.096) | (1.325) | (1.468) |
| Medium high tech | 1.699 | 0.0492 | 2.450*** | 2.450*** | 2.035*** | 2.035*** | 3.178*** | 3.178*** | 2.191* | 2.191 |
| | (1.496) | (0.149) | (0.579) | (0.917) | (0.622) | (0.740) | (1.191) | (1.121) | (1.283) | (1.397) |
| Medium low tech | 1.308 | -0.439*** | 2.431*** | 2.431*** | 1.989*** | 1.989*** | 3.594*** | 3.594*** | 2.731** | 2.731* |
| | (1.495) | (0.149) | (0.582) | (0.932) | (0.624) | (0.753) | (1.197) | (1.132) | (1.288) | (1.425) |
| Low tech | 1.118 | -0.613*** | 2.426*** | 2.426*** | 1.919*** | 1.919** | 4.267*** | 4.267*** | 3.068** | 3.068** |
| | (1.475) | (0.148) | (0.579) | (0.918) | (0.621) | (0.757) | (1.191) | (1.112) | (1.282) | (1.537) |
| Electricity | 0.192 | -0.00933 | -1.014 | -1.014 | -1.898** | -1.898* | -1.990 | -1.990 | -3.169** | -3.169* |
| | (1.922) | (0.179) | (0.708) | (1.149) | (0.763) | (0.989) | (1.457) | (1.457) | (1.582) | (1.911) |
| Market service low | -1.477 | 0.0414 | 3.066*** | 3.066*** | 2.637*** | 2.637*** | 4.670*** | 4.670*** | 3.895*** | 3.895** |
| | (1.534) | (0.153) | (0.593) | (0.933) | (0.635) | (0.757) | (1.218) | (1.066) | (1.310) | (1.562) |
| Financial services | 0.718 | 0.443*** | 3.286*** | 3.286*** | 2.852*** | 2.852*** | 2.657** | 2.657** | 1.645 | 1.645 |
| | (1.716) | (0.158) | (0.610) | (0.951) | (0.656) | (0.777) | (1.256) | (1.173) | (1.356) | (1.570) |
| High tech services | 1.471 | 0.174 | 1.457** | 1.457 | 1.136* | 1.136 | 1.671 | 1.671 | 0.506 | 0.506 |
| | (1.659) | (0.155) | (0.605) | (0.911) | (0.647) | (0.704) | (1.247) | (1.132) | (1.337) | (1.469) |
| Low tech services | -1.732 | 1.153*** | 2.747*** | 2.747*** | 2.408*** | 2.408*** | 4.219*** | 4.219*** | 3.488*** | 3.488** |
| | (1.639) | (0.151) | (0.614) | (0.913) | (0.657) | (0.706) | (1.260) | (1.127) | (1.354) | (1.520) |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Austria | -13.02*** | 8.812*** | 2.330* | 2.330 | 1.313 | 1.313 | -19.88*** | -19.88*** | -23.74*** | -23.74*** |
| | (1.932) | (0.215) | (1.362) | (1.499) | (1.859) | (2.269) | (2.772) | (2.779) | (3.819) | (3.831) |
| Belgium | -15.37*** | 8.887*** | 0.608 | 0.608 | -0.313 | -0.313 | -18.67*** | -18.67*** | -21.65*** | -21.65*** |
| | (2.067) | (0.207) | (1.423) | (1.643) | (1.917) | (2.379) | (2.909) | (3.106) | (3.950) | (3.795) |
| Bulgaria | -14.07*** | 7.198*** | 3.891*** | 3.891*** | 2.868 | 2.868 | -11.49*** | -11.49*** | -14.74*** | -14.74*** |
| | (1.672) | (0.221) | (1.251) | (1.448) | (1.797) | (2.229) | (2.546) | (2.640) | (3.696) | (3.807) |
| Czech republic | -24.64*** | 7.870*** | 4.922*** | 4.922*** | 3.685* | 3.685 | -8.074** | -8.074** | -10.75** | -10.75** |
| | (1.808) | (0.266) | (1.684) | (1.901) | (2.144) | (2.678) | (3.432) | (3.428) | (4.402) | (4.338) |
| Denmark | -14.39*** | 8.494*** | 0.463 | 0.463 | -0.575 | -0.575 | -16.86*** | -16.86*** | -20.10*** | -20.10*** |
| | (1.766) | (0.197) | (1.355) | (1.513) | (1.857) | (2.295) | (2.765) | (2.860) | (3.822) | (3.716) |
| Estonia | -14.83*** | 6.762*** | 3.966*** | 3.966*** | 2.951* | 2.951 | -15.63*** | -15.63*** | -19.26*** | -19.26*** |
| | (1.746) | (0.202) | (1.232) | (1.415) | (1.787) | (2.238) | (2.510) | (2.556) | (3.676) | (3.606) |
| Spain | -17.65*** | 8.908*** | 3.904*** | 3.904** | 2.933 | 2.933 | -16.03*** | -16.03*** | -18.65*** | -18.65*** |
| | (1.677) | (0.217) | (1.504) | (1.685) | (1.985) | (2.437) | (3.064) | (3.208) | (4.078) | (3.969) |
| Finland | -22.28*** | 9.244*** | 2.345 | 2.345 | 1.406 | 1.406 | -11.27*** | -11.27*** | -13.92*** | -13.92*** |
| | (1.952) | (0.247) | (1.689) | (1.945) | (2.151) | (2.629) | (3.441) | (3.589) | (4.416) | (4.297) |
| France | -18.64*** | 8.744*** | 3.216** | 3.216* | 2.079 | 2.079 | -15.80*** | -15.80*** | -18.94*** | -18.94*** |
| | (2.215) | (0.240) | (1.545) | (1.720) | (2.021) | (2.530) | (3.159) | (3.286) | (4.163) | (4.208) |
| Greece | -21.89*** | 2.327*** | 8.025*** | 8.025*** | 6.358*** | 6.358*** | 3.194 | 3.194 | -1.170 | -1.170 |
| | (2.522) | (0.263) | (1.298) | (1.571) | (1.831) | (2.268) | (2.652) | (2.603) | (3.771) | (3.795) |
| Hungary | -16.33*** | 7.583*** | 0.498 | 0.498 | -0.394 | -0.394 | -16.91*** | -16.91*** | -18.95*** | -18.95*** |
| | (2.563) | (0.282) | (1.576) | (1.704) | (2.078) | (2.592) | (3.225) | (3.294) | (4.268) | (4.119) |
| Ireland | -19.64*** | 9.228*** | 4.060** | 4.060** | 3.132 | 3.132 | -17.30*** | -17.30*** | -20.06*** | -20.06*** |
| | (4.077) | (0.262) | (1.673) | (1.777) | (2.125) | (2.488) | (3.386) | (3.582) | (4.343) | (3.964) |
| Lithuania | -10.88*** | 6.376*** | -0.0759 | -0.0759 | -0.771 | -0.771 | -13.61*** | -13.61*** | -16.84*** | -16.84*** |
| | (1.804) | (0.188) | (1.080) | (1.290) | (1.671) | (2.151) | (2.210) | (2.263) | (3.447) | (3.365) |
| Luxemburg | -17.26*** | 9.016*** | 0.993 | 0.993 | 0.738 | 0.738 | -18.20*** | -18.20*** | -21.00*** | -21.00*** |
| | (2.951) | (0.247) | (1.557) | (1.719) | (2.027) | (2.338) | (3.193) | (3.172) | (4.182) | (4.132) |
| Latvia | -8.782*** | 6.395*** | 1.673 | 1.673 | 1.004 | 1.004 | -18.52*** | -18.52*** | -21.53*** | -21.53*** |
| | (1.860) | (0.302) | (1.050) | (1.222) | (1.651) | (2.045) | (2.134) | (2.199) | (3.396) | (3.336) |
| Netherlands | -26.25*** | 9.251*** | 6.518*** | 6.518*** | 5.629** | 5.629** | -8.399** | -8.399** | -10.79** | -10.79** |
| | (2.123) | (0.279) | (1.862) | (2.097) | (2.308) | (2.795) | (3.791) | (3.801) | (4.734) | (4.409) |
| Norway | -20.09*** | 9.822*** | 2.594 | 2.594 | 1.850 | 1.850 | -17.80*** | -17.80*** | -20.35*** | -20.35*** |
| | (1.801) | (0.230) | (1.641) | (1.804) | (2.106) | (2.580) | (3.347) | (3.428) | (4.329) | (4.118) |
| Portugal | -20.00*** | 8.176*** | 1.731 | 1.731 | 0.622 | 0.622 | -9.143*** | -9.143*** | -11.91*** | -11.91*** |
| | (2.013) | (0.241) | (1.539) | (1.725) | (2.022) | (2.525) | (3.137) | (3.163) | (4.154) | (4.013) |
| Romania | -18.69*** | 6.614*** | 3.515** | 3.515** | 2.614 | 2.614 | -3.714 | -3.714 | -6.970* | -6.970* |
| | (1.869) | (0.231) | (1.397) | (1.583) | (1.908) | (2.360) | (2.845) | (2.798) | (3.918) | (3.815) |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sweden | -17.84*** | 9.316*** | -0.983 | -0.983 | -1.774 | -1.774 | -20.04*** | -20.04*** | -22.56*** | -22.56*** |
| | (1.925) | (0.220) | (1.535) | (1.741) | (2.016) | (2.515) | (3.132) | (3.247) | (4.146) | (4.112) |
| Slovenia | -11.60*** | 7.854*** | 0.478 | 0.478 | -0.311 | -0.311 | -16.61*** | -16.61*** | -19.41*** | -19.41*** |
| | (1.937) | (0.186) | (1.222) | (1.404) | (1.757) | (2.188) | (2.498) | (2.488) | (3.622) | (3.422) |
| Slovakia | -21.02*** | 7.723*** | 5.443*** | 5.443*** | 4.622** | 4.622* | -10.56*** | -10.56*** | -12.71*** | -12.71*** |
| | (2.868) | (0.300) | (1.560) | (1.724) | (2.047) | (2.529) | (3.178) | (3.167) | (4.204) | (3.950) |
| Italy | -18.24*** | 8.808*** | 2.803* | 2.803 | 1.872 | 1.872 | -10.20*** | -10.20*** | -13.08*** | -13.08*** |
| | (1.650) | (0.220) | (1.512) | (1.714) | (1.992) | (2.436) | (3.081) | (3.145) | (4.092) | (3.994) |
| Constant | 10.38*** | 1.354*** | 5.421*** | 5.421*** | 5.346*** | 5.346*** | 10.60*** | 10.60*** | 10.49*** | 10.49*** |
| | (0.268) | (0.00857) | (0.0362) | (0.0612) | (0.0383) | (0.0686) | (0.0924) | (0.0747) | (0.0981) | (0.0811) |
| Observations | 13,472 | 12,471 | 14,316 | 14,316 | 12,411 | 12,411 | 15,220 | 15,220 | 13,194 | 13,194 |

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 6. Tobit estimation results, new to the firm and new to the market products. Model 3

| | Design eq | R&D eq | INNO equation: New-to-the firm products | | | | INNO equation: New-to-the-market products | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | d | e | f | c | d | e | f |
| VARIABLES | | | No interactions model | No interactions model Bootstrapped std errors | SME and Large firms' interactions | SME and Large firms' interactions Bootstrapped std errors | No interactions model | No interactions model Bootstrapped std errors | SME and Large firms' interactions | SME and Large firms' interactions Bootstrapped std errors |
| latentstar_design | | 0.0527*** | 0.469*** | 0.469*** | | | 1.312*** | 1.312*** | | |
| | | (0.00810) | (0.0462) | (0.0444) | | | (0.0938) | (0.0884) | | |
| latentstar_R&D | | | 0.667*** | 0.667*** | | | 1.750*** | 1.750*** | | |
| | | | (0.0913) | (0.0981) | | | (0.185) | (0.199) | | |
| design_sme* | | | | | 0.466*** | 0.466*** | | | 1.316*** | 1.316*** |
| | | | | | (0.0497) | (0.0433) | | | (0.101) | (0.107) |
| design_big* | | | | | 0.473*** | 0.473*** | | | 1.367*** | 1.367*** |
| | | | | | (0.0532) | (0.0516) | | | (0.109) | (0.111) |
| R&D_sme* | | | | | 0.568*** | 0.568*** | | | 1.533*** | 1.533*** |
| | | | | | (0.0968) | (0.100) | | | (0.197) | (0.200) |
| R&D _big* | | | | | 0.823*** | 0.823*** | | | 2.164*** | 2.164*** |
| | | | | | (0.122) | (0.137) | | | (0.251) | (0.251) |
| sme | | | | | 2.387* | 2.387* | | | 6.747** | 6.747** |
| | | | | | (1.285) | (1.414) | | | (2.652) | (2.959) |
| New marketing strategies | 1.129*** | | 0.0461 | 0.0461 | 0.0148 | 0.0148 | 0.455** | 0.455** | 0.412* | 0.412* |
| | (0.354) | | (0.113) | (0.0974) | (0.120) | (0.123) | (0.228) | (0.206) | (0.244) | (0.215) |
| Competitiveness | 1.022*** | | | | | | | | | |
| | (0.371) | | | | | | | | | |
| Funding | | 0.535*** | | | | | | | | |
| | | (0.0272) | | | | | | | | |
| R&Dconstant | | 0.913*** | | | | | | | | |
| | | (0.0284) | | | | | | | | |
| Lack of financial resources | | -0.00265 | | | | | | | | |
| | | (0.0263) | | | | | | | | |
| New design (aesthetic changes) | | | 1.297*** | 1.297*** | 1.299*** | 1.299*** | 2.288*** | 2.288*** | 2.413*** | 2.413*** |
| | | | (0.101) | (0.113) | (0.107) | (0.110) | (0.204) | (0.219) | (0.217) | (0.204) |
| Cooperating firm | | | 0.470*** | 0.470*** | 0.410*** | 0.410*** | 1.434*** | 1.434*** | 1.460*** | 1.460*** |
| | | | (0.102) | (0.0902) | (0.109) | (0.107) | (0.207) | (0.213) | (0.222) | (0.262) |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Clients as source of information | 2.620*** | | 0.292* | 0.292 | 0.249 | 0.249 | -1.302*** | -1.302*** | -1.386*** | -1.386*** |
| | (0.381) | | (0.176) | (0.223) | (0.186) | (0.180) | (0.357) | (0.417) | (0.379) | (0.389) |
| Patent activity | 1.512*** | 0.490*** | | | | | | | | |
| | (0.465) | (0.0335) | | | | | | | | |
| Trademarks | 1.592*** | | | | | | | | | |
| | (0.373) | | | | | | | | | |
| lnemp | 0.0393 | 0.663*** | 0.219*** | 0.219*** | 0.149* | 0.149* | -1.088*** | -1.088*** | -1.177*** | -1.177*** |
| | (0.137) | (0.00979) | (0.0758) | (0.0827) | (0.0904) | (0.0848) | (0.154) | (0.161) | (0.184) | (0.179) |
| group | -0.402 | 0.285*** | 0.198* | 0.198 | 0.213* | 0.213 | 0.472** | 0.472* | 0.585** | 0.585*** |
| | (0.398) | (0.0284) | (0.113) | (0.128) | (0.122) | (0.154) | (0.229) | (0.242) | (0.247) | (0.213) |
| High tech | 1.434 | 0.574*** | 2.483*** | 2.483*** | 2.081*** | 2.081*** | 2.755** | 2.755* | 1.789 | 1.789 |
| | (1.507) | (0.152) | (0.597) | (0.742) | (0.640) | (0.764) | (1.223) | (1.432) | (1.312) | (1.595) |
| Medium high tech | 1.017 | 0.152 | 2.562*** | 2.562*** | 2.139*** | 2.139*** | 3.021** | 3.021** | 2.136* | 2.136 |
| | (1.380) | (0.147) | (0.574) | (0.712) | (0.616) | (0.728) | (1.177) | (1.309) | (1.266) | (1.541) |
| Medium low tech | 0.945 | -0.364** | 2.399*** | 2.399*** | 1.947*** | 1.947** | 3.111*** | 3.111** | 2.331* | 2.331 |
| | (1.379) | (0.148) | (0.577) | (0.693) | (0.619) | (0.762) | (1.184) | (1.363) | (1.273) | (1.537) |
| Low tech | 0.635 | -0.544*** | 2.464*** | 2.464*** | 1.952*** | 1.952** | 4.046*** | 4.046*** | 2.930** | 2.930* |
| | (1.358) | (0.147) | (0.574) | (0.684) | (0.616) | (0.760) | (1.178) | (1.375) | (1.267) | (1.540) |
| Electricity | -0.493 | 0.0347 | -0.547 | -0.547 | -1.424* | -1.424 | -0.549 | -0.549 | -1.764 | -1.764 |
| | (1.810) | (0.178) | (0.708) | (0.916) | (0.763) | (1.038) | (1.451) | (1.575) | (1.574) | (1.751) |
| Market service low | -1.801 | 0.0417 | 3.436*** | 3.436*** | 3.040*** | 3.040*** | 6.250*** | 6.250*** | 5.491*** | 5.491*** |
| | (1.420) | (0.152) | (0.592) | (0.726) | (0.635) | (0.813) | (1.214) | (1.350) | (1.305) | (1.561) |
| Financial services | 0.511 | 0.479*** | 3.442*** | 3.442*** | 3.035*** | 3.035*** | 3.238*** | 3.238** | 2.295* | 2.295 |
| | (1.605) | (0.157) | (0.608) | (0.737) | (0.654) | (0.709) | (1.250) | (1.532) | (1.348) | (1.611) |
| High tech services | 1.704 | 0.208 | 1.168* | 1.168 | 0.849 | 0.849 | 0.645 | 0.645 | -0.447 | -0.447 |
| | (1.536) | (0.155) | (0.604) | (0.770) | (0.646) | (0.779) | (1.241) | (1.349) | (1.330) | (1.648) |
| Low tech services | -1.810 | 1.142*** | 3.177*** | 3.177*** | 2.892*** | 2.892*** | 6.260*** | 6.260*** | 5.525*** | 5.525*** |
| | (1.521) | (0.150) | (0.611) | (0.760) | (0.654) | (0.849) | (1.251) | (1.408) | (1.343) | (1.767) |
| Austria | -12.68*** | 8.542*** | 4.813*** | 4.813*** | 4.039** | 4.039** | -8.035*** | -8.035*** | -11.94*** | -11.94*** |
| | (1.836) | (0.206) | (1.303) | (1.288) | (1.803) | (1.801) | (2.638) | (2.600) | (3.689) | (3.979) |
| Belgium | -15.12*** | 8.580*** | 3.504*** | 3.504** | 2.839 | 2.839 | -4.815* | -4.815 | -7.933** | -7.933** |
| | (1.832) | (0.194) | (1.359) | (1.387) | (1.856) | (1.946) | (2.764) | (2.941) | (3.810) | (3.869) |
| Bulgaria | -13.52*** | 6.895*** | 6.403*** | 6.403*** | 5.606*** | 5.606*** | 0.628 | 0.628 | -2.703 | -2.703 |
| | (1.559) | (0.209) | (1.187) | (1.185) | (1.738) | (1.757) | (2.406) | (2.576) | (3.563) | (3.877) |
| Czech republic | -24.35*** | 7.388*** | 9.099*** | 9.099*** | 8.191*** | 8.191*** | 11.53*** | 11.53*** | 8.428** | 8.428* |
| | (1.699) | (0.239) | (1.597) | (1.570) | (2.059) | (2.090) | (3.241) | (3.274) | (4.215) | (4.591) |
| Denmark | -14.17*** | 8.194*** | 3.243** | 3.243** | 2.466 | 2.466 | -3.884 | -3.884 | -7.200* | -7.200* |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1.658) | (0.184) | (1.293) | (1.310) | (1.799) | (1.849) | (2.624) | (2.738) | (3.688) | (3.911) |
| Estonia | -14.72*** | 6.465*** | 6.613*** | 6.613*** | 5.825*** | 5.825*** | -3.079 | -3.079 | -6.807* | -6.807* |
| | (1.645) | (0.189) | (1.176) | (1.157) | (1.735) | (1.738) | (2.385) | (2.477) | (3.557) | (3.811) |
| Spain | -17.32*** | 8.544*** | 7.234*** | 7.234*** | 6.555*** | 6.555*** | -0.304 | -0.304 | -3.128 | -3.128 |
| | (1.558) | (0.199) | (1.433) | (1.403) | (1.917) | (1.942) | (2.904) | (3.010) | (3.924) | (4.145) |
| Finland | -21.94*** | 8.802*** | 6.242*** | 6.242*** | 5.655*** | 5.655*** | 7.166** | 7.166** | 4.242 | 4.242 |
| | (1.856) | (0.223) | (1.600) | (1.572) | (2.066) | (2.033) | (3.244) | (3.251) | (4.228) | (4.413) |
| France | -22.19*** | 8.592*** | 8.393*** | 8.393*** | 7.543*** | 7.543*** | 5.151 | 5.151 | 1.881 | 1.881 |
| | (1.779) | (0.245) | (1.616) | (1.562) | (2.080) | (2.082) | (3.286) | (3.409) | (4.266) | (4.435) |
| Greece | -21.53*** | 1.892*** | 11.34*** | 11.34*** | 9.953*** | 9.953*** | 18.78*** | 18.78*** | 14.28*** | 14.28*** |
| | (2.481) | (0.242) | (1.243) | (1.379) | (1.778) | (1.808) | (2.532) | (2.454) | (3.654) | (3.911) |
| Hungary | -18.85*** | 7.403*** | 4.956*** | 4.956*** | 4.358** | 4.358* | 1.493 | 1.493 | -0.566 | -0.566 |
| | (2.188) | (0.282) | (1.615) | (1.547) | (2.106) | (2.411) | (3.290) | (3.768) | (4.311) | (4.906) |
| Ireland | -19.67*** | 8.862*** | 7.841*** | 7.841*** | 7.224*** | 7.224*** | 0.345 | 0.345 | -2.627 | -2.627 |
| | (4.116) | (0.247) | (1.615) | (1.469) | (2.067) | (2.015) | (3.250) | (3.588) | (4.207) | (4.396) |
| Lithuania | -10.71*** | 6.146*** | 1.961* | 1.961* | 1.446 | 1.446 | -3.883* | -3.883* | -7.117** | -7.117** |
| | (1.710) | (0.181) | (1.032) | (1.102) | (1.627) | (1.700) | (2.101) | (2.144) | (3.343) | (3.630) |
| Luxemburg | -17.03*** | 8.679*** | 4.228*** | 4.228*** | 4.246** | 4.246** | -3.076 | -3.076 | -6.087 | -6.087 |
| | (2.914) | (0.234) | (1.493) | (1.428) | (1.964) | (1.866) | (3.048) | (3.163) | (4.039) | (3.948) |
| Latvia | -9.846*** | 6.272*** | 4.078*** | 4.078*** | 3.568** | 3.568** | -8.334*** | -8.334*** | -11.26*** | -11.26*** |
| | (1.669) | (0.301) | (1.053) | (1.050) | (1.642) | (1.639) | (2.129) | (2.230) | (3.364) | (3.768) |
| Netherlands | -27.08*** | 8.765*** | 11.40*** | 11.40*** | 10.91*** | 10.91*** | 13.95*** | 13.95*** | 11.17** | 11.17** |
| | (1.818) | (0.254) | (1.790) | (1.740) | (2.236) | (2.239) | (3.628) | (3.552) | (4.571) | (4.691) |
| Norway | -19.94*** | 9.419*** | 6.281*** | 6.281*** | 5.863*** | 5.863*** | -0.428 | -0.428 | -3.246 | -3.246 |
| | (1.668) | (0.209) | (1.556) | (1.530) | (2.025) | (2.064) | (3.158) | (3.142) | (4.148) | (4.388) |
| Portugal | -18.94*** | 7.724*** | 4.896*** | 4.896*** | 4.128** | 4.128** | 6.563** | 6.563** | 3.627 | 3.627 |
| | (1.814) | (0.217) | (1.433) | (1.497) | (1.924) | (1.889) | (2.908) | (2.901) | (3.940) | (4.144) |
| Romania | -19.36*** | 6.279*** | 7.339*** | 7.339*** | 6.706*** | 6.706*** | 13.21*** | 13.21*** | 9.719** | 9.719** |
| | (1.719) | (0.217) | (1.372) | (1.401) | (1.880) | (1.906) | (2.784) | (2.706) | (3.849) | (4.069) |
| Sweden | -17.70*** | 8.950*** | 2.318 | 2.318 | 1.822 | 1.822 | -4.508 | -4.508 | -7.220* | -7.220* |
| | (1.768) | (0.202) | (1.457) | (1.447) | (1.942) | (1.981) | (2.958) | (2.974) | (3.979) | (4.037) |
| Slovenia | -10.96*** | 7.609*** | 2.720** | 2.720** | 2.106 | 2.106 | -5.907** | -5.907*** | -8.845** | -8.845** |
| | (1.844) | (0.178) | (1.169) | (1.255) | (1.706) | (1.732) | (2.375) | (2.284) | (3.503) | (3.940) |
| Slovakia | -18.50*** | 7.148*** | 8.125*** | 8.125*** | 7.641*** | 7.641*** | 3.939 | 3.939 | 1.484 | 1.484 |
| | (2.470) | (0.275) | (1.404) | (1.368) | (1.907) | (1.852) | (2.847) | (2.814) | (3.907) | (4.068) |
| Italy | -18.13*** | 8.425*** | 6.184*** | 6.184*** | 5.548*** | 5.548*** | 5.718** | 5.718* | 2.627 | 2.627 |
| | (1.537) | (0.201) | (1.437) | (1.433) | (1.920) | (1.948) | (2.915) | (2.963) | (3.933) | (4.136) |
| Constant | 10.57*** | 1.354*** | 5.401*** | 5.401*** | 5.324*** | 5.324*** | 10.52*** | 10.52*** | 10.41*** | 10.41*** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (0.261) | (0.00857) | (0.0361) | (0.0598) | (0.0381) | (0.0679) | (0.0916) | (0.0900) | (0.0972) | (0.0971) |
| Observations | 16,334 | 12,491 | 14,333 | 14,333 | 12,429 | 12,429 | 15,245 | 15,245 | 13,220 | 13,220 |

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 7. Tobit estimation results, new to the firm and new to the market products. Model 4

| | Design eq | R&D eq | INNO equation: New-to-the firm products | | | | INNO equation: New-to-the firm products | | |
|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | d | e | f | c | d | e |
| VARIABLES | | | No interactions model | No interactions model Bootstrapped std errors | SME and Large firms' interactions | SME and Large firms' interactions Bootstrapped std errors | No interactions model | No interactions model Bootstrapped std errors | SME and Large firms' interactions |
| latentstar_design | | 0.0683*** | 0.324*** | 0.324*** | | | 0.543*** | 0.543*** | |
| | | (0.00697) | (0.0332) | (0.0347) | | | (0.0665) | (0.0498) | |
| latentstar_R&D | | | 0.826*** | 0.826*** | | | 2.105*** | 2.105*** | |
| | | | (0.101) | (0.117) | | | (0.202) | (0.204) | |
| design_sme* | | | | | 0.325*** | 0.325*** | | | 0.569*** |
| | | | | | (0.0359) | (0.0325) | | | (0.0720) |
| design_big* | | | | | 0.338*** | 0.338*** | | | 0.624*** |
| | | | | | (0.0427) | (0.0416) | | | (0.0858) |
| R&D_sme* | | | | | 0.735*** | 0.735*** | | | 1.914*** |
| | | | | | (0.107) | (0.0980) | | | (0.214) |
| R&D _big* | | | | | 1.033*** | 1.033*** | | | 2.675*** |
| | | | | | (0.134) | (0.132) | | | (0.271) |
| sme | | | | | 2.718** | 2.718* | | | 8.256*** |
| | | | | | (1.327) | (1.635) | | | (2.709) |
| New design (aesthetic changes) | 2.428*** | | | | | | | | |
| | (0.361) | | | | | | | | |
| Competitiveness | 1.249*** | | | | | | | | |
| | (0.399) | | | | | | | | |
| funding | | 0.526*** | | | | | | | |
| | | (0.0292) | | | | | | | |
| R&Dconstant | | 0.912*** | | | | | | | |
| | | (0.0299) | | | | | | | |
| Cooperating firm | | 0.334*** | 0.166 | 0.166* | 0.103 | 0.103 | 0.755*** | 0.755*** | 0.781*** |
| | | (0.0287) | (0.116) | (0.0996) | (0.125) | (0.123) | (0.233) | (0.254) | (0.250) |
| New marketing concepts/strategies | | | 0.752*** | 0.752*** | 0.726*** | 0.726*** | 2.194*** | 2.194*** | 2.162*** |
| | | | (0.101) | (0.0831) | (0.108) | (0.110) | (0.202) | (0.232) | (0.216) |
| Complexity of design | | | 0.551*** | 0.551*** | 0.558*** | 0.558*** | 1.976*** | 1.976*** | 2.053*** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | (0.112) | (0.0846) | (0.119) | (0.105) | (0.223) | (0.204) | (0.237) |
| Registration of design patterns | | | 0.747*** | 0.747*** | 0.703*** | 0.703*** | 1.952*** | 1.952*** | 1.914*** |
| | | | (0.132) | (0.0983) | (0.143) | (0.112) | (0.263) | (0.294) | (0.284) |
| Existence of valid patents | 1.615*** | | | | | | | | |
| | (0.465) | | | | | | | | |
| Lack of financial resources | 0.476 | -0.0647 | | | | | | | |
| | (0.415) | (0.0283) | | | | | | | |
| Lack of qualified personnel | 0.936** | | | | | | | | |
| | (0.444) | | | | | | | | |
| Lack of information on markets | -0.415 | | | | | | | | |
| | (0.442) | | | | | | | | |
| Clients as source of information | 2.358*** | | 0.683*** | 0.683*** | 0.608*** | 0.608*** | 0.880*** | 0.880*** | 0.727** |
| | (0.401) | | (0.152) | (0.158) | (0.161) | (0.156) | (0.306) | (0.304) | (0.323) |
| lnemp | 0.124 | 0.665*** | 0.0807 | 0.0807 | -0.0253 | -0.0253 | -1.266*** | -1.266*** | -1.414*** |
| | (0.145) | (0.0104) | (0.0828) | (0.0922) | (0.0983) | (0.0912) | (0.166) | (0.167) | (0.197) |
| group | -0.254 | 0.270*** | 0.0424 | 0.0424 | 0.0393 | 0.0393 | 0.0713 | 0.0713 | 0.145 |
| | (0.423) | (0.0298) | (0.115) | (0.128) | (0.124) | (0.121) | (0.231) | (0.296) | (0.250) |
| High tech | 0.806 | 0.771*** | 2.601*** | 2.601*** | 2.205*** | 2.205** | 3.582*** | 3.582*** | 2.632* |
| | (1.714) | (0.181) | (0.700) | (0.964) | (0.744) | (0.886) | (1.389) | (1.363) | (1.484) |
| Medium high tech | 0.472 | 0.400** | 2.707*** | 2.707*** | 2.326*** | 2.326** | 3.687*** | 3.687*** | 2.869** |
| | (1.585) | (0.176) | (0.675) | (0.951) | (0.719) | (0.908) | (1.342) | (1.270) | (1.436) |
| Medium low tech | 0.486 | -0.139 | 2.554*** | 2.554** | 2.158*** | 2.158** | 3.839*** | 3.839*** | 3.176** |
| | (1.580) | (0.177) | (0.675) | (0.993) | (0.718) | (0.891) | (1.342) | (1.263) | (1.435) |
| Low tech | -0.00970 | -0.342* | 2.748*** | 2.748*** | 2.283*** | 2.283** | 4.777*** | 4.777*** | 3.807*** |
| | (1.562) | (0.176) | (0.672) | (0.988) | (0.715) | (0.909) | (1.335) | (1.231) | (1.429) |
| Electricity | 0.241 | 0.118 | -1.197 | -1.197 | -2.067** | -2.067* | -2.555 | -2.555 | -3.462** |
| | (1.998) | (0.206) | (0.798) | (1.061) | (0.854) | (1.143) | (1.598) | (1.941) | (1.721) |
| Market service low | -2.409 | 0.283 | 3.381*** | 3.381*** | 2.963*** | 2.963*** | 5.026*** | 5.026*** | 4.407*** |
| | (1.619) | (0.181) | (0.688) | (0.985) | (0.732) | (0.941) | (1.366) | (1.251) | (1.461) |
| Financial services | 0.113 | 0.565*** | 3.623*** | 3.623*** | 3.178*** | 3.178*** | 3.329** | 3.329** | 2.413 |
| | (1.795) | (0.185) | (0.705) | (0.968) | (0.753) | (0.916) | (1.405) | (1.332) | (1.508) |
| High tech services | 0.616 | 0.436** | 1.572** | 1.572 | 1.183 | 1.183 | 2.191 | 2.191* | 1.071 |
| | (1.760) | (0.184) | (0.705) | (0.964) | (0.748) | (0.931) | (1.404) | (1.265) | (1.497) |
| Low tech services | -2.092 | 1.364*** | 2.678*** | 2.678*** | 2.434*** | 2.434*** | 4.183*** | 4.183*** | 3.509** |
| | (1.725) | (0.179) | (0.708) | (0.942) | (0.752) | (0.935) | (1.405) | (1.317) | (1.502) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Austria | -13.00*** | 8.583*** | 1.948 | 1.948 | 0.859 | 0.859 | -20.03*** | -20.03*** | -25.47*** |
| | (2.000) | (0.227) | (1.244) | (1.721) | (1.784) | (1.966) | (2.491) | (2.264) | (3.612) |
| Belgium | -15.19*** | 8.549*** | 0.361 | 0.361 | -0.558 | -0.558 | -18.60*** | -18.60*** | -23.08*** |
| | (2.130) | (0.213) | (1.242) | (1.721) | (1.790) | (2.008) | (2.503) | (1.966) | (3.636) |
| Bulgaria | -13.48*** | 6.820*** | 3.627*** | 3.627** | 2.561 | 2.561 | -11.80*** | -11.80*** | -16.53*** |
| | (1.749) | (0.228) | (1.081) | (1.518) | (1.685) | (1.887) | (2.163) | (1.762) | (3.415) |
| Czech republic | -24.41*** | 7.381*** | 4.970*** | 4.970*** | 3.950** | 3.950** | -8.668*** | -8.668*** | -12.61*** |
| | (1.878) | (0.244) | (1.302) | (1.761) | (1.836) | (1.895) | (2.616) | (1.968) | (3.719) |
| Denmark | -14.40*** | 8.243*** | 0.233 | 0.233 | -0.816 | -0.816 | -16.88*** | -16.88*** | -21.62*** |
| | (1.847) | (0.205) | (1.198) | (1.653) | (1.750) | (1.989) | (2.406) | (1.968) | (3.550) |
| Estonia | -15.31*** | 6.360*** | 4.247*** | 4.247*** | 3.233* | 3.233* | -15.17*** | -15.17*** | -20.17*** |
| | (1.829) | (0.210) | (1.054) | (1.493) | (1.671) | (1.865) | (2.113) | (1.604) | (3.387) |
| Spain | -17.81*** | 8.562*** | 3.776*** | 3.776** | 2.837 | 2.837 | -16.24*** | -16.24*** | -20.37*** |
| | (1.761) | (0.215) | (1.267) | (1.778) | (1.809) | (1.949) | (2.541) | (2.036) | (3.662) |
| Finland | -21.73*** | 8.826*** | 2.079 | 2.079 | 1.256 | 1.256 | -11.95*** | -11.95*** | -16.13*** |
| | (2.013) | (0.233) | (1.362) | (1.956) | (1.890) | (2.019) | (2.736) | (2.255) | (3.827) |
| France | -17.81*** | 8.428*** | 2.544** | 2.544 | 1.477 | 1.477 | -17.11*** | -17.11*** | -21.82*** |
| | (2.280) | (0.237) | (1.298) | (1.864) | (1.833) | (2.049) | (2.617) | (2.149) | (3.722) |
| Greece | -22.17*** | 1.859*** | 8.483*** | 8.483*** | 6.946*** | 6.946*** | 2.323 | 2.323 | -3.071 |
| | (2.564) | (0.249) | (1.030) | (1.541) | (1.635) | (1.922) | (2.070) | (1.672) | (3.319) |
| Hungary | -17.04*** | 7.056*** | -0.637 | -0.637 | -1.754 | -1.754 | -18.72*** | -18.72*** | -22.25*** |
| | (2.618) | (0.287) | (1.513) | (2.151) | (2.041) | (2.266) | (3.080) | (3.114) | (4.151) |
| Ireland | -19.42*** | 8.688*** | 4.115*** | 4.115** | 3.232* | 3.232 | -17.09*** | -17.09*** | -21.30*** |
| | (4.058) | (0.258) | (1.408) | (1.827) | (1.912) | (1.973) | (2.802) | (2.431) | (3.848) |
| Lithuania | -10.42*** | 5.925*** | -0.144 | -0.144 | -0.878 | -0.878 | -13.52*** | -13.52*** | -18.08*** |
| | (1.870) | (0.205) | (0.973) | (1.473) | (1.612) | (1.909) | (1.956) | (1.603) | (3.274) |
| Luxemburg | -16.85*** | 8.595*** | 0.796 | 0.796 | 0.584 | 0.584 | -18.23*** | -18.23*** | -22.51*** |
| | (2.984) | (0.249) | (1.347) | (1.808) | (1.868) | (1.833) | (2.728) | (2.667) | (3.802) |
| Latvia | -8.953*** | 5.913*** | 1.815* | 1.815 | 1.059 | 1.059 | -17.75*** | -17.75*** | -22.14*** |
| | (1.935) | (0.318) | (0.985) | (1.354) | (1.623) | (1.901) | (1.964) | (1.608) | (3.287) |
| Netherlands | -25.70*** | 8.846*** | 6.010*** | 6.010*** | 5.319*** | 5.319*** | -9.989*** | -9.989*** | -13.94*** |
| | (2.176) | (0.251) | (1.450) | (2.016) | (1.962) | (2.036) | (2.912) | (2.348) | (3.970) |
| Portugal | -19.71*** | 7.709*** | 1.651 | 1.651 | 0.637 | 0.637 | -9.487*** | -9.487*** | -13.69*** |
| | (2.067) | (0.233) | (1.247) | (1.807) | (1.796) | (1.930) | (2.503) | (2.004) | (3.637) |
| Romania | -19.15*** | 6.199*** | 3.805*** | 3.805** | 3.011* | 3.011* | -3.561 | -3.561** | -8.007** |
| | (1.951) | (0.226) | (1.139) | (1.630) | (1.721) | (1.818) | (2.282) | (1.769) | (3.483) |
| Sweden | -17.74*** | 8.991*** | -1.287 | -1.287 | -2.030 | -2.030 | -20.26*** | -20.26*** | -24.31*** |
| | (1.988) | (0.218) | (1.301) | (1.880) | (1.841) | (1.970) | (2.618) | (2.201) | (3.734) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Slovenia | -11.51*** | 7.396*** | 0.643 | 0.643 | -0.222 | -0.222 | -15.62*** | -15.62*** | -19.89*** |
| | (2.008) | (0.203) | (1.106) | (1.628) | (1.688) | (1.957) | (2.224) | (1.833) | (3.426) |
| Slovakia | -21.51*** | 7.197*** | 5.716*** | 5.716*** | 5.035*** | 5.035*** | -10.44*** | -10.44*** | -13.96*** |
| | (2.869) | (0.289) | (1.269) | (1.706) | (1.819) | (1.858) | (2.543) | (1.930) | (3.683) |
| Italy | -18.42*** | 8.511*** | 2.710** | 2.710 | 1.829 | 1.829 | -10.26*** | -10.26*** | -14.63*** |
| | (1.732) | (0.215) | (1.268) | (1.750) | (1.808) | (1.953) | (2.544) | (2.064) | (3.662) |
| Constant | 10.31*** | 1.376*** | 5.412*** | 5.412*** | 5.352*** | 5.352*** | 10.49*** | 10.49*** | 10.37*** |
| | (0.271) | (0.00901) | (0.0373) | (0.0508) | (0.0397) | (0.0730) | (0.0934) | (0.0822) | (0.0993) |
| Observations | 12,835 | 11,668 | 13,443 | 13,443 | 11,629 | 11,629 | 14,341 | 14,341 | 12,410 |

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 8. Elasticities of innovative sales to design and R&D investments.

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| design_sme* | 0.334*** | 0.362*** | 0.501*** | 0.381*** |
| design_big* | 0.344*** | 0.377*** | 0.508*** | 0.394*** |
| R&D_sme* | 0.795*** | 0.688*** | 0.568*** | 0.735*** |
| R&D_big* | 1.121*** | 0.954*** | 0.823*** | 1.033*** |

The sum of the direct and indirect effects of design expenditures are reported.

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**Abstract**

The objective of this study is to provide an analysis of the importance of design – defined as the procedures, choice of elements and technical preparation to implement a new product – and R&D investment as drivers in European firms' innovation performance. In doing so, it partly compensates for the lack of empirical evidence in the literature by using non-anonymised data from the third wave of the European CIS, and estimating a system of simultaneous equations to tackle the endogeneity inherent in these investment choices and the externalities associated with them. In addition, the two main variables of interest are continuous, which is different from the majority of CIS-based studies. The robustness of results confirms the crucial role of design investment for innovation success in 18 European countries for both the manufacturing and service sectors. In particular it found an increase of 1% expenditure increases innovation sales by between 0.34% and 0.49%, while the same increase in R&D investment increases innovation sales by between 0.64% and 0.86%. Interestingly, while investing in design shows similar innovation output returns for small, medium-sized and large enterprises, this is not the case for R&D investment. While the latter is not surprising, the former is, to the extent that one believes larger firms are better internally organised than SMEs. All in all, the empirical evidence confirms design as a complement to technological R&D and as a driver for user-centred incremental (new-to-the-firm) and radical (new-to-the-market) innovations. The policy conclusions are clear: design is a less costly alternative to R&D for many SMEs and a policy of supporting design should be considered, as this might be a more cost-efficient support strategy.

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