JRC Technical Notes

IPTS WORKING PAPER on
CORPORATE R&D AND INNOVATION - No. 08/2011

Design and European firms' innovative performance: A less costly innovation activity for European SMEs?

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December 2011

JRC EUROPEAN COMMISSION

Institute for Prospective Technological Studies

DIRECTORATE GENERAL FOR RESEARCH AND INNOVATION
EUROPEAN COMMISSION

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The author of this paper is Daria Ciriaci. The work has benefited from the input of Hugo Hollanders and Sandro Montresor to earlier versions of the paper.

The *IPTS Working Papers on Corporate R&D and Innovation* are published under the editorial responsibility of Fernando Hervás, Pietro Moncada-Paternò-Castello and Andries Brandsma at the Knowledge for Growth Unit – Economics of Industrial Research and Innovation Action of IPTS / Joint Research Centre of the European Commission, Michele Cincera of the Solvay Brussels School of Economics and Management, Université Libre de Bruxelles, and Enrico Santarelli of the University of Bologna.

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DG RTD-C website: http://ec.europa.eu/invest-in-research/monitoring/analyses01_en.htm

IPTS WORKING PAPER on CORPORATE R&D AND INNOVATION - No. 08/2011
Full electronic version of the paper can be downloaded at http://iri.jrc.es/

JRC 68197
EUR 24747 EN/8
ISBN 978-92-79-23102-5
ISSN 1831-9408
ISSN 1831-9424
doi:10.2791/72880

Luxembourg: Publications Office of the European Union

Abstract

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 addition, it specifically analyses whether a firm's size affects the amount spent on design and the return in terms of innovation output to this activity. In doing so, it partly compensates for the lack of empirical evidence in the literature by using data from the European CIS. Unlike the majority of CIS-based studies, continuous variables for both R&D and design expenditure are used. Results confirm the crucial role of design investment for incremental and radical innovations in 23 European countries for both the manufacturing and services sectors. In particular it found that an increase of 1% expenditure raises the sales of new-to-the-firm products by 0.34%, while the same increase in R&D investment raises innovative sales by 0.88%. These returns are significantly higher in the case of radical innovations, i.e. new-t-the-market products (0.66% and 2.2%). Interestingly, while investing in design shows no statistically different returns for small, medium-sized and large enterprises, this is not the case for R&D expenditure. The policy conclusions are clear: design is a less costly alternative to R&D for many SMEs.

Keywords: Intangible assets, design, R&D investments, CIS, CDM model.

1 Introduction

The importance of design as new product development has grown dramatically over recent decades due to globalisation and the fragmentation of markets into ever-smaller niches where a firm compete on the base of corporate intangible resources and knowledge assimilation (Schilling and Hill, 1998). All in all, investment in design creates a firm-specific knowledge (Polanyi, 1967; Grant, 1996; Lane and Lubatkin, 1998) of a tacit and not easily transferable nature, which in turn sustains a firm's specific competitive advantage (Penrose, 1959; Wenerfelt, 1984; Rumelt, 1984; Barney, 1986; Dierickx and Cool, 1989; Peteraf, 1993). However, although there is general agreement that rational, well-planned product development and technological innovation play a crucial role in improving the competitiveness of products (Tolke et al., 2009), firms and national economies (Hertenstein et al., 2005; Roy and Riedel, 1997; Urban and Hauser, 1993; Rothwell and Gardiner, 1983), contributing to differentiating the product (Winter, 1987; Kogut and Zander, 1992; Conner and Prahalad, 1996; Barney et al., 2001), solid and influential references on company strategies towards it are scarce[1] (Acha, 2008).

Therefore, the present study aims at partly compensating for the lack of international and cross-sector empirical evidence providing an analysis of the determinants of the choice about the amount of design expenditure – defined as the procedures, choice of elements and technical preparation to implement a new product – by innovative firm[2] and of its importance as driver of European firms' innovation performance[3]. As such, it investigates if the success of an innovation (new to the firm and/or new to the market) is explained by design expenditures, focusing on European innovative firms. In addition, as to the best of my knowledge the literature does not provide a clear-cut prediction on how the amount spent on new product development activities and the return to them[4] differ according to a firm's size, this paper assesses also whether they differ between European small and medium-sized

[1] Reviewing the literature in this field of research is made difficult by the lack of a common definition and the 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 this investment.

[2] In the spirit of innovation surveys, a innovative firm is defined as a firm that has had introduced a new or strongly improved product and/or used new or strongly improved production processes during the period under review, and whether a firm has ongoing or abandoned innovation activities (OECD, 2005).

[3] Process innovations were excluded because typically one firm's process innovation is another (upstream) firm's product innovation.

[4] 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.

(SMEs) and large enterprises. In fact, as design activities do not require scientific knowledge or sophisticated technological equipment, are characterized by lower capital intensity and a shorter pay-back period (less than two years) than R&D activities (French Ministry of Economy, 2002; European Commission, 2009), they may be particularly relevant to SMEs.

The study pursues these aims using data from the third wave of the European CIS[5] which was elaborated at the Eurostat SAFE centre in Luxembourg and 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), the last wave disclosing information on the amount of design expenditures at European level, a feature which allowed the use - unlike the majority of CIS-based studies - of continuous variables for the three main variables of interest (R&D and design expenditures, and innovative sales).

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 explains the methodology used to analyse the relationship between design, R&D and innovation and the data. The results are discussed in Section 4; and, finally, Section 5 focuses on the policy implications of the study.

2 Literature review

Compared to R&D and science and technology, commonly recognised as fundamental drivers of innovation, the understanding of the role and nature of design is definitely less developed (Acha, 2008). Although there is an established common belief that "good" design boost firms' performance and growth (Hollanders and van Cruysen, 2009; Hertenstein *et al*., 2005), its quantitative contribution to business's financial performances has been the object of few number of studies. While the existence of the Frascati Manual and an agreed definition of R&D have facilitated the collection and widespread analysis of R&D statistics, it is difficult to obtain a clear view on the impact of design expenditure on a firm's performance due to the lack of a common definition and understanding of design (Roy and Riedel 1997, Talke et al., 2009): is it an activity (*to design)* and/or the result of this activity? (*design)*.

Besides deciding which activities should be considered as design activities, there are several other issues that make the analysis of a firm's design investment and its impact on market

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

performance within a common theoretical framework difficult. Firstly, research on design as new product development splits into two broad areas of enquiry (an economic and an organisational ones; Adler, 1989; Brown and Eisenhardt, 1995), which have different analysis units and, consequently, very different methodological approaches. However, both traditions suggest that design expenditure is crucial to link creativity to the market and that complementarities among a firm's activities (R&D, design, marketing, training etc.) and its departments enhance product development success. The use of a common theoretical framework is made difficult also by the, there is a lack of agreement on the channels through which design activities can be used to improve product competitiveness (Roy and Riedel, 1997): 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 to offer a completely new product.[6] Designing products with other features superior to those of competitors 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). 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).

The economic-oriented literature 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. 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). The organizational tradition, commonly known as the new product development approach (NPD), focuses instead on how specific products are developed within a firm and on the project team itself (who actually carry out the task product development). According to the 'rational plan' strand of the NPD literature, successful product development is the result of rational planning and execution. Stated simply, products are more likely to succeed when they have a market place advantage, are targeted to an attractive market and are 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,

[6] 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 user; whereas for non-price competitiveness, it may do so via its impact on product performance, reliability, appearance, safety and ease of use, etc. (Roy and Potter, 1993).

1992). This in turn helps team members understand the design process quicker and more comprehensively, and enhances the design process performance (Clark and Fujimoto, 1991; Zirger and Maidaque, 1990).

In line with this idea, using British data, Lambert (2006) stated that the design input into the innovation process has the most impact when used with more technological-based input. This suggests 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 input and other innovation and economic performance indicators provided by the third wave of the UK Community Innovation Survey (CIS). Estimating a knowledge production function, an output production 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 was 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). A report by the OECD (2000) stressed how design expenditure is crucial for SME innovation, which 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 (compared to R&D) and to the short (less than two years) pay-back period (French Ministry of Economy, 2002). Last but not least, the uncertainty due to this expenditure may be considered significantly lower that that which is characteristically linked to R&D.

This study contributes to the aforementioned research fields by proposing an empirical model relying on the theoretical hypothesis of the complementary nature of different innovation inputs and firm-specific resources generally involved in the process of new product development (i.e. organisational practices and routines, Nelson and Winter, 1982; Barney et al., 2001).

3 Methodology and Data

3.1 Methodology

When modelling the impact of design and R&D investment on a firm's innovative performance, there is a series of aspects to be considered. Firstly, R&D and design investments are endogenous (Crepon et al., 1998) 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). Secondly, investments in design and R&D are likely to result in 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). Thirdly, innovation is the output of a complex process to which several innovation inputs contribute (Talke et al., 2009; Guidetti and Mazzanti, 2007).

To tackle these issues, following the approach of Crepon et al. (1998) a system of three equations has been used[7]. The first equation (DS) links a firm's design expenditure to its determinants; the second equation (*RD*) represents the R&D relationship, i.e. links a firm's R&D decisions to its determinants; finally, the third equation (*INNO*) relates design and research to innovation output. As such, the third equation shows that creativity and design are linked to innovation (Bitard and Basset, 2008; Swann and Birke[8], 2005). In fact, innovation is the exploitation of 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. 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).

The model is structured as follows:

[7] Within this methodological framework, tailored to take advantage of the innovation survey data, endogeneity and selectivity are specifically taken into account.

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

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

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 ε_{TR}, ε_{HK}, and ε_{INNO} are normally distributed error terms with zero mean and $\sigma^2_{t,}$ σ^2_h and σ^2_i standard deviation, respectively.

The use of the two latent variables (DS* and Rd*) and not of their observed values is justified on both methodological grounds (i.e. it is 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 because the inclusion of the predicted design and R&D efforts 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). In addition, using the predicted values instead of the actual ones is a sensible way to measure innovation and to deal with the simultaneity issue between R&D/design and the expectation of innovation success (Hall et al., 2009).

3.2. Data

The Community Innovation Survey is coordinated by the European Commission and carried out by the Member States. In the CIS questionnaire, firms are asked first to provide general information on their economic activity, sales, number of employees etc. The second part of the questionnaire contains questions about the innovation activities of firms, the percentage sales from new product/services, partnerships in innovation activities, sources of knowledge used to produce innovations etc. In most cases, the European CIS available at the Eurostat's safe center provides only the amount spent by firms on R&D and the possibility to know whether (yes/no) a firm has also spent on other three innovation activities: training, marketing and design. However, the third wave of the CIS (1998-2000) is an exception, as it is the last wave for which Member States had to provide to the Eurostat information both on the amount spent on R&D and the total amount spent on the aforementioned other three innovation activities. In fact, among those firms that engaged in technological innovation between 1998 and 2000 (20,920 out of 61,540[9] firms were innovators under the CIS definition) the CIS[10] asked if a firm invested in training, marketing and/or design in 2000 (labelled *rothx* in CIS 3). Before explaining how the amount spent on design was calculated, it is worth clarifying that according to the CIS's definition of design expenditure, this is those costs due to the procedures and technical preparations to implement actual products (goods and services) and process innovation, which is not covered elsewhere in the questionnaire. In other words, design expenditure is defined as being due to production changes and to quality control procedures, methods and standards and associated software required to produce new products or processes (namely, tooling up and industrial engineering); 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; expenditure for testing technologically new or improved products or services, and acquiring the machinery, tools and equipment for the implementation of new or improved products or services (see OECD Oslo manual, 1995). [11]

3.3. Innovation inputs and outputs

The identification strategy followed to isolate the effect of design expenditure on a firm's innovativeness, consisted of using those firms that declared that they have invested in design and not in marketing and training (in this case the amount spent on design coincides with *rothx*, i.e. the total amount spent on other than R&D innovation activities). This sub-sample (1,445 firms, 9.2% of the product innovators in the dataset) is then compared to the rest of the innovative firms that did not engage in design activities[12], but that could have engaged (or not) in other innovative activities (i.e. R&D, marketing and training; almost 14,150 firms). The drawback of this identification strategy is the underestimation of the number of firms that actually invested in design, as those that invested also in marketing

[9] The original dataset was removed for firms that reported zero turnover or zero employees.
[10] The UK CIS is an exception as it treats design separately from other R&D activities by asking companies for design expenditure.
[11] As recommended by the OECD (2002 and 2005), in the CIS questionnaire some industrial design activities (such as prototyping and industrial design required during R&D) are included in the definition of R&D, to avoid measurement problems due to the fact that some of the activities generally considered to be part of the product development process overlap with the initial R&D phase. Moreover, in the CIS design expenditures do not overlap with marketing expenditures either, as there is a direct question on each category of expenditure.

aimed directly at launching new or significantly improved products *and* training are excluded from the sample (8,668 firms; see Table 1)[13]. However, this strategy is the only one to allow the direct and indirect effects of the amount of expenditure on design on a firm innovative performance to be identified. In addition, it reduces the likely underestimation of design expenditures, which might be more probable in firms where R&D and/or marketing have a higher status than "design" (Tether, 2005). If R&D and marketing are prominent functions, design may be *silent* (Gorb and Dumas, 1987)[14] 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[15]. According to this definition used, the average expenditure on design 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 is €19,500.

Therefore, the dependent variable *DS* is the natural logarithm of the firm's design expenditure in 2000. The R&D effort is measured using the natural logarithm of the expenditure in external and internal R&D in 2000[16] (*RD* in the system of equation). Finally, *INNO* is the natural logarithm of a firm's innovative sales. As in the CIS it is possible to distinguish between innovative sales as products which are "new" only to the firm (i.e. incremental innovations) and those that are "new" to the firm and to the market (i.e. breakthrough innovations), the system of equations has been estimated once for new to the firm products and once for new to the market products. Therefore, the innovation output is calculated firstly by 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 then 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*.

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[12] 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.

[13] 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 training, but not in marketing.

[14] 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).

15 In fact, the extent to which firms record design expenditure 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 over-estimated.

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

3.3. Econometric model

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 expenditure or zero innovative sales[17]. They are estimated once measuring the innovation output by the sales of new to the firm product and once by the sales of new to the market product. As, unlike Heckman's selection models, no correlation between the selection error terms and outcome equation is allowed, the latter was estimated with bootstrap re-sampling procedures[18] (Efron 1982) using 50 replications to check for robustness and consistent estimates. Finally, it is worth noting that given the cross-section structure of the CIS, the causality links between variables are generally considered "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. Standard checks for outliers were performed and only very few abnormal values of design expenditure were identified (and removed from the observations).

The explanatory variables included in the system of equations are explained below. For the sake of simplicity, 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). Their choice is based on the literature, but some exclusion restrictions were imposed to ensure parameter identification in each of the three equations (Greene, 2007). In addition, some variables were significant in one equation, and not in the others, and *viceversa*. For instance, a dummy identifying firms that cooperated with other competitors and/or institutions was not a significant explanatory variable of the amount spent on new product development, while it was significant in explaining RD expenditure. Table 1 describes the dependent and explanatory variables included and the usual descriptive statistics. In the following, the names of the independent variables used are reported in brackets and *italics*.

[17] Consequently, the three dependent variables are censored variables.
[18] Results do not significantly differ, and are available on request.

3.3.1 The common set of independent variables

The common set of significant independent variables (z_c) includes the firm's size (*lnempl*), 23 country controls, 9 sector controls and a dummy for whether a firm belongs to a group or not (*group*; see Table 2 for a description). The control for the size of the firm was introduced because it is generally recognized that large firms tend to exploit economies of scale and scope in a better way. Larger firms usually have easier access to finance through reinvested profits and bank loans as a way of financing expensive innovation. 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). Yet there may be diminishing returns to R&D, which affect large more than small firms. Consequently, the R&D advantage of large firms is reduces (Acs and Audretsch, 1991). Country dummies were included to account for heterogeneity as the overall quality of a country's educational system, its openness towards different countries and culture determine its creative climate[19] (Hollanders and van Cruysen, 2009) and creativity results. In addition, these country dummies may capture differences in IPR regimes[20], which have a fundamental role in creating incentives for firms to adopt new methods of production and new knowledge (Howkins, 2005). As far as the sector controls are 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. 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). To minimise the effects of industry-specific factors of production and structure, sectors were controlled for by inserting dummies for low, low-

[19] 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).

[20] In the case of intangible resources like design and R&D, so that they are 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.

medium, medium-high and high-tech manufacturing and services sectors, following the Eurostat classification. 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).

3.3.2 The specific to the design expenditure equation variables

Besides the aforementioned common structural variables, in the equation aiming at explaining the amount of a firm expenditure in design other a series of variables suggested by the literature were inserted. Firstly, given the focus on design as a source of competitive 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. 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. Secondly, a dummy for those firms that implemented advanced management techniques during the period 1998-2000 (*advanced management strategies*) was included. According to Hertenstein and Platt (1998) controlling for the role of human resource management within a firm is necessary because design teams are generally cross-functional and a firm which is up-to-date in terms of management techniques may manage the process according to which a new product is passed from one department to the other (e.g., R&D, design, marketing and distribution) more successfully[21]. As designing requires several disciplines and develops strong coordination competencies, the return on innovative 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 addition, 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. Finally, a series of variables 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

[21] Furthermore, this variable is important as it indirectly enters the INNO equation through the DS* latent variable (*latentstar de*).

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 inputs. 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 accounting for the role of users as a source of information, the more user-driven firms are expected to invest more in designing their innovative products.

3.3.3 The specific to the R&D equation variables

Given the well-known positive impact of public funding on corporate R&D investment (Bérubé and Mohnen, 2007; Busom, 2000; David et al., 2000) a dummy controlling for those firms that received financial support for innovation activities from local or regional authorities, central government or the European Union was inserted (*funding*), 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. These firms with intensive and continuous 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). As such, a dummy for cooperation in innovative activities with other enterprises or institutions over the same period (*cooperating firm*; Coen and Levinthal

1990)[22] was used. These last three dummies are expected to be positive in the *RD-pers* equation as they were inserted to control for continuous and established R&D.

3.3.4 The specific to the innovation output equation variables

In the basic *INNO* equation (i.e. 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 latter dummy was included for completeness, as the definition of design used in this study does not include pure changes in the aesthetic appearance of a product. Instead, both product development and pure product design are likely to have a positive impact on a firm's financial and innovative performance (Talke et al., 2009). 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). Finally, as design helps to convey the abstract features of a product to the user, it "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). That is why a dummy was introduced to control for those firms that identified their customers as a main source of information for suggesting new innovative 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).

To test whether, *ceteris paribus*, design expenditure and R&D expenditure have the same impact on innovation in small and medium-sized enterprises and larger firms, two interaction terms for each of the two latent variables *latentstar de** and *latentstar rdtot** were inserted (latent design in SME: *design sme*; latent design in big firms: *design big*; latent R&D

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

personnel in SME: *lnred sme*; and latent R&D in big firms: *lnred big*). 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 scale of production effect is expected (i.e., higher R&D returns for larger firms). On the other side, the return on design expenditure is not expected to be affected by the scale of production, as the structural nature of product development processes are likely to give a firm an advantage irrespective of its size. Clearly, in the augmented INNO equation, also a dummy identifying small and medium-sized enterprises (*sme*) was inserted.

4 Results

This section describes the results obtained from estimating the aforementioned system of equations. Table 3 reports the estimation results of the three equations for both new-to-the-firm and new-to-the-market products. In the 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 in column *f* the same estimates are obtained through bootstrap re-sampling. The results were robust and confirmed for both new-to-the-firm and new-to-the-market products as far as the sign of the variables and their significance are concerned. For the innovative sales equation (the third of the structural system), comments focus more on its augmented version (i.e., with the interaction terms, column *d*). Finally, it is worth reiterating 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 the amount of design expenditure. This result confirms the potentiality of design activities for SMEs, and differs from previous empirical studies (e.g., see Design Council, 2007). In addition, in line with previous studies (e.g., see Tether, 2005) attitudes to the use of design are not concentrated in particular sectors. Design expenditure is distributed across sectors, unlike R&D investment which tends to be concentrated in large firms in some high-tech sectors. At the same time, results corroborate the crucial role of the "competition" driver (*competitiveness*): on average a firm competing in international markets invests in design slightly more (1.27%) than a firm operating in national markets. 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 positive in the DS equation. This is also the case for having protected inventions or innovations developed internally with formal methods such as trademarks or with more strategic-oriented ones such as a complex design and/or secrecy during the period 1998-2000. These strategies always have a positive influence on the amount of design expenditure. Closeness to user needs (*clients as a source of information*) is found to be significant and positive. This suggests 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 belonging to a group; a firm's size (Lichtenberg and Siegel, 1991; Cohen and Klepper, 1996); and receiving public funding (from local/regional authorities, central government and/or the European Union; *funding*) during the period 1998-2000. 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 in 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 that did not follow 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 within a given 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 spreading advantage[23]. In

[23] 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 based on innovation and,

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. In addition, market services and high tech services were positive and significant in the equation, while low tech services were not.

Results 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 (Talke et al., 2009). Design is a significant creative input to technological innovation (beyond R&D): by confining attention to R&D investment, a significant part of the picture is missed. Design expenditure has a direct return on new-to-the-firms products sales of 0.34 (considering the sum of the direct effects and indirect - through the R&D equation), while that on R&D is 0.86. In the case of new-to-the-firms products, i.e. radical innovations, the elasticity on design expenditure and R&D are significantly higher and equal, respectively, to 0.78 and 2.2. 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. This is confirmed also by the fact that the impact of introducing changes in the product's appearance is significant and positive for both incremental and radical innovation. Finally, it is worth to remind that as these two key variables enter the INNO equation as latent ones, they capture not only the firm's single expenditure efforts in design and R&D, but also the externalities associated with them.

Previous results are confirmed also when the interaction terms for SMEs and large firms are inserted in the INNO equation. In the case of new-to-the-firm products, the return on design expenditure is 0.33% for a SME (*design sme**) and 0.34% for larger firms (*design big**; see Table 4 for a summary of the main results). In the case of new-to-the-market products, once the direct and indirect impact of design expenditure is accounted for, the elasticity is 0.77% for SMEs and 0.84% for non-SMEs. In both cases, as shown by the Ftest, the slight differences in the return on design expenditures observed between SME and large firms are not statistically significant. For the elasticity of new-to-the-firm product sales to R&D (*R&D_sme** and *R&D _big**), the result is 0.77% for SMEs and 1.1% for large firms, and in the case of new-to-the-market products is 2.1% versus 2.8%. Unlike the previous case, this time the Ftest on linear restrictions suggested that these differences are statistically

consequently, the output over which they expect to apply their R&D is closely related to their output when conducting the R&D. Therefore, these two conditions together mean that the larger a firm's output when R&D are conducted, the greater the incentive to invest in R&D.

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), 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). Finally, the impact of product design (*new design, aesthetic changes*) is always positive and significant too.

The finding that return on design expenditure is not affected by the production scale supports the idea that this type of investment is 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 a product's uniqueness (Brown and Eisenhardt, 1995), irrespective of a firm's size. In addition, it was found that the amount of design expenditure is not affected by the scale of production (DS equation). This suggests that given their lower capital intensity and shorter pay-back period firms may not need to spread this cost over a larger scale of production to decrease their average costs, as with R&D investment. Furthermore, the scale of production does not even influence the return on these expenditures, 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 return on pure aesthetic changes in a firm's product appearance, and in this case, the elasticities of innovative sales did not differ between SME and large firms either.[24] 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 address 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 turned out to be a significant and positive determinant of a firm's innovation performance. Moreover, the empirical findings confirm that pure design

[24] Results are available on request.

innovation is a significant explanatory variable of the innovative 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. 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.[25]

5 Conclusions & policy implications

Using a large dataset of European firms, this study analysed the determinants and the impact of a firm's expenditure in new product development activities on firm's innovative sales. First of all, it found that the amount of design expenditure is not affected either by a firm's scale of production and by its sector of activity, but is strongly and positively influenced by the implementation of strategic protection tools (patents, registration of design patterns, secrecy, design complexity) by the firm, i.e. by the firm's ability to prevent valuable information from reaching other firms. Secondly, the estimates confirm also the crucial role of new product development and R&D expenditures for a firm's ability to sell new products. According to results, an increase of 1% in a firm's design expenditures (i.e. in the product development process) increases the sales of new-to-the-firm products by 0.34% and those of new-to-the-market products by 0.78%. The elasticity of innovative sales to R&D is 0.86 in the case of new-to-the-firm products, and 2.2 in the case of new-to-the-market. Therefore, results seem to suggest that returns to these two intangible investments are significantly higher for radical than incremental innovations.

All in all, the estimates confirm the potential relevance of design to SMEs. As repeatedly pointed out by the European Commission (2011) 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 in which firms innovate. Design is one of these ways. In fact, investing in design shows similar return in terms of innovation output in small and medium-sized enterprises and large firms. Design investment 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 scale of production.

[25] 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.

This is not the case, instead, for R&D investments: if we consider the case of new-to-the-firm products the elasticity of innovative sales to R&D is 0.77% for SMEs and 1.1% for large firms (the same trend is registered in the case of new-to-the-market products). Stated simply, *ceteris paribus*, the same amount of investment in R&D shows significantly higher than average return 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. Furthermore, while the amount spent on R&D varies significantly with the sector, design expenditure turned out to be sector-independent.

So far, the policy conclusions seem clear: design emerges as a less costly alternative to R&D for many SMEs and support the EC strategy of enhancing non-R&D innovation in SMEs and in low-tech 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). However, is there a market failure to justify public support to design? Although there is no simple answer to this question, the results presented partly support the view that there is not a justification for *ad-hoc* policy intervention. In fact, whereas R&D activities are especially prone to economies of scale, incomplete information, externalities and increasing returns, i.e. to market failures, in the case of design none of these phenomena seems to be crucial. The empirical evidence commented so far shown that economies of scale do not operate. Therefore, a firm can break even if it sells at marginal cost, and the large scale producer can not always undercut a smaller scale producer. In addition, the asymmetric information and the uncertainty which leads, for instance, to under investment in R&D seem limited due to the lower level of uncertainty which is inherent to new product development design investment. Besides, it is reasonable to argue that most companies have adequate information about the benefits of design to their business in order to ensure that there is no market failure in spending on design for competitive advantage. On the other side, however, if design reduces negative externalities (i.e. leads to an efficient use of space, of energy etc), and/or in presence of labour turnover for design specialists, it is likely that there will be market failure. However, those aspects of design concerned with the "link from creativity to innovation" and the use of design to offer a competitive distinction, i.e. as a part of a firm's competitive strategy, are less likely to suffer from such market failures.

Concluding, design opens the innovation process and constitutes the industrial architecture within which innovation takes place, and 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.

Acknowledgments

The authors would like to thank Fernando Hervás, Pietro Moncada-Paterno'-Castello (Euro-pean Commission, IPTS /Joint Research Centre), Hugo Hollanders (MERIT), Sandro Montresor (Euro-pean Commission, IPTS /Joint Research Centre and University of Bologna), Enrico Saltarelli (University of Bologna) and Michele Cincera (Solvay Brussels School of Economics and Management, Université Libre de Bruxelles) for their detailed and useful review comments on a previous version of the paper.

The paper has also benefited from the discussion which followed its presentation during a lunch-seminar at the Bank of Italy (April, 2012). In particular, the author wishes to thank Francesca Lotti for her helpful comments.

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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	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 for the whole CIS3 sample.

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 sales <=50,000,000, zero otherwise.	79845	.9228881	.2667706	0	1
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	33808	.7198888	.44906	0	1

	information needed for suggesting new innovation projects during the period 1998-2000, zero otherwise.					
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 product's appearance/design during the period 1998-2000, zero otherwise.	85863	.2448435	.4299969	0	1
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	84236	.0859134	.2802378	0	1

	design complexity as strategic method over the years 1998-2000, zero otherwise.					
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 Tobit estimation results, new to the firm and new to the market products (without and with bootstrapped std errors).

	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			0.342***	0. 342***			0.783***	0.783***		
			(0.0349)	(0.0409)			(0.0744)	(0.0853)		
latentstar_R&D			0.883***	0.883***			2.210***	2.210***		
			(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	ns	-0.0270								
		(0.0276)								
Cooperating firm	ns	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**	0.589***								
	(0.480)	(0.0345)								
Registration of design patterns	2.567***									
	(0.542)									
Trademarks	1.592***									
	(0.373)									
Secrecy	0.771*									
	(0.400)									
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)
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)
Other controls: Country dummies.										
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 4. Elasticities of innovative sales to design and R&D investments.

	New to the firms products	New to the market products
design_sme*	0.33***	0.77***
design_big*	0.34***	0.84***
R&D_sme*	0.770***	2.04***
R&D_big*	1.099***	2.82***

European Commission
EUR 24747EN/8– Joint Research Centre – Institute for Prospective Technological Studies
IPTS WORKING PAPER on CORPORATE R&D AND INNOVATION - No. 08/2011
Title: Design and European firms' innovative performance: A less costly innovation activity for European SMEs?
Author(s): Daria Ciriaci (European Commission, Joint Research Centre - Institute for Prospective Technological Studies)
Luxembourg: Publications Office of the European Union
2011
EUR – Scientific and Technical Research series – ISSN 1831-9408
Technical Note – ISSN 1831-9424
ISBN 978-92-79-23102-5
doi:10.2791/72880

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 addition, it specifically analyses whether a firm's size affects the amount spent on design and the return in terms of innovation output to this activity. In doing so, it partly compensates for the lack of empirical evidence in the literature by using data from the European CIS. Unlike the majority of CIS-based studies, continuous variables for both R&D and design expenditure are used. Results confirm the crucial role of design investment for incremental and radical innovations in 23 European countries for both the manufacturing and services sectors. In particular it found that an increase of 1% expenditure raises the sales of new-to-the-firm products by 0.34%, while the same increase in R&D investment raises innovative sales by 0.88%. These returns are significantly higher in the case of radical innovations, i.e. new-t-the-market products (0.66% and 2.2%). Interestingly, while investing in design shows no statistically different returns for small, medium-sized and large enterprises, this is not the case for R&D expenditure. The policy conclusions are clear: design is a less costly alternative to R&D for many SMEs.

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LF-NH-24747-EN-N

JRC
EUROPEAN COMMISSION

Publications Office

ISBN 978-92-79-23102-5

9 789279 231025