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Design, innovation and performance in European firms[1]

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Abstract

This paper provides some new theoretical speculations and empirical evidence on the relationship between design, innovation and economic performance at the firm level. We posit that design investments may provide firms with a higher capacity of introducing product/process innovations, but that the ensuing economic performance is rather associated to the role of design within the firm. Moreover, once controlled for the firm's non-technological innovativeness and other knowledge-production inputs, the role of design does also relate to the introduction of innovative products and/or processes. We provide a systematic empirical test for these arguments on a sample of more than 12,000 European firms from the last EC Innobarometer survey. The econometric estimates are consistent with our expectations. However, while a higher innovativeness is also associated with a non-systematic resort to design, a higher innovation-based performance is coupled with an increasingly more central role of design, providing this is at least non-occasional. Innovations do actually look "design-led" overall, but innovating successfully apparently requires the firm to retain such a driver central to its business model.

Keywords: design, innovation, firm performance.

JEL Classification: O31, O32, O33.

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1. Introduction

The role of design in driving firm performance appears nowadays nearly guaranteed. Such a role is actually supported by a rich stream of research, which has progressively refined the analysis of design with respect to its function within the firm - aesthetic vs. engineering - and the kind of performance it impacts on - market share vs. profitability (e.g. Roy and Riedel, 1997; Gemsers and Lenders, 2001; Hertenstein et al., 2005; Chiva and Alegre, 2007).

An important position along this debate has been recognised to innovation. On the one hand, design activities favour novel production engineering and product creativity, leading firms to a higher innovation capacity. A remarkable recent example is represented by Rolls-Royce Holding, celebrated by the UK council for having put design at the centre of an innovative kind of "Knowledge-Based Engineering" (KBE), allowing for a free-form car modelling (Design Council, 2015). Even more evident is the contribution of design to product innovations, when it "drives" new product meanings for the customer - such as for the popular Swatch watches - or when it changes the aesthetics of a product - such as for the "stylistic innovations" that pervade the furniture industry (e.g. Alessi's product line, "Family Follows Fiction") (Ravasi e Stgliani, 2012; Verganti, 2008).

On the other hand, design-driven and design-led innovations (for this and other distinctions, see Galindo-Rueda and Millot, 2015) have also been argued and found to affect the economic performance of firms (Moultrie and Livesey, 2014). The UK design council also documents notable cases of companies, whose turnover grew up thanks to design-based innovative strategies, like Fudge Kitchen and Morgan Motor Company (Design Council, 2015). Kartell and Luceplan are other two remarkable examples of design-driven innovations, leading to successful economic performance in the Italian furniture industry (e.g. Dell'Era et al., 2010).

This paper focuses on the relationship between design and innovation and re-asses the impact of design on firm performance in two original respects. First, from a theoretical point of view, we distinguish design investments from the role of design within the firm, arguing that they have a different impact on the firm's capacity to innovate and on the economic returns from innovating. Second, from an empirical point of view, we integrate the extant case-study-based evidence on the relationship at stake by searching for a systematic confirmation of our arguments on a large sample of firms.

By combining design with innovation studies, we put forward two sets of hypothesis on the relationship between design and firm's innovativeness, on the one hand, and between design and innovation "marketability", on the other hand. Using the last Innobarometer survey on European firms (2015), we run an econometric model that test for these hypotheses, by plugging different design related variables among the regressors of an augmented knowledge-production function and of an explicative function of its economic returns. Our results provide consistent evidence of the driving role of design investments for product/process innovations. However, they suggest that a similar role is also played by the way design is retained and possibly managed

within the firm, even when this is not systematic. On the contrary, design investments are not associated with a higher innovative turnover, which instead increases with an increasingly more central consideration of design within the firm, providing it is not occasional. The implications of these results are twofold. On the one hand, design investments should only be used as a leverage to increase the firm's capacity of introducing product and/or process innovations, with no guarantee of an economic success from doing so. On the other hand, in order to increase the marketability of their innovations, firms should also retain design as pivotal for their activities and manage it accordingly.

The rest of the paper is structured as follows. In Section 2, we review the relevant literature and position our research hypotheses within it. Section 3 illustrates our empirical application, the dataset and the econometric strategy. In Section 4 we discuss the results, while Section 5 presents some conclusive remarks.

2. Background literature and research hypotheses

The impact that design can have on firm performance has been analysed since long in the academic research. In the '90s, the topic was put at the centre of notable research projects - like MADRID ("MArket Demands that Reward Investments in Design") and CID ("Commercial Impacts of Design") - following which a consistent amount of literature was produced (e.g. Roy and Potter, 1993; Roy and Riedel, 1997; Ulrich and Pearson, 1998). In general, supportive conclusions were drawn on the role of design for the competitive success of firms in terms of, for example, profitability and turnover (e.g. Black and Baker, 1987; Walsh et al., 1992). In particular, industrial design investments were conceptualised as a driver of firms' competitiveness through quality and non-price competition.

In the following two decades, the research on design and firm performance has progressed substantially, moving important steps ahead with respect to the still "rudimentary theoretical underpinning, conceptualising, and measuring" issues of the first generation of studies (Gemsers and Lenders, 2001, p. 29). The conceptualisation of design has gone over the early focus on industrial design, and the theoretical rationale of its impact has extended beyond its role for price vs. non-price competition. Different domains of design functionality have been recognised, such as the interpretation of consumers' needs, the organisational design of the company structure, the formulation of the firm's strategy, and its model of value creation. This new understanding came from the convergence of several disciplines like economics, management, engineering and artificial sciences, creativity and arts, innovation and aesthetics. As the survey by D'Ippolito (2014) shows, this has also entailed a proliferation of definitions and a substantial "multidimensionalisation" of the concept of design. With the inevitable risk of an excessive simplification, it seems to us these approaches represent important qualifications and integrations of a sort of "baseline" twofold account of design, which we embrace in the current study. In a nutshell, design can be meant as "… the creation of […] product shapes and styles, ... [and the] communicat[ion] of the firm's quality image and product integrity" (Yamamoto and

Lambert, 1994). In other words, we refer to a concept of design that encompasses both "functionality" and "aesthetics", and retain its role in both the creation of new products and services and in their commercialisation (Moultrie and Livesey, 2014).

The most recent empirical analyses have moved towards this comprehensive account of design and brought novel, and generally supportive, evidence of its role in driving firm performance (e.g. Hertensteinet al., 2005; Candi, 2006; Chiva and Alegre, 2007; Candi and Saemundsson, 2011; Filippetti, 2011; Hertenstein et al., 2013). To be sure, along these studies, a further evolution in the theoretical underpinning of the design-performance relationship and in its empirical analysis emerged. One of the most important acquisitions is represented by the crucial (though not exclusive) role of innovation for the impact of design on firm performance (e.g. Walsh, 1996; von Stamm, 2003; Perks et al., 2005; Marsili and Salter, 2006; Tether, 2006). This is the focal relationship of this paper, and indeed one that needs to be carefully disentangled along the research hypotheses that we put forward in the following. In particular, we claim that it is crucial to distinguish, on the one hand, between the firm's innovativeness and its innovation-related performance and, on the other hand, between design investments and the role of design within the firm.

First, one needs to consider the firm's innovativeness as such, meant as its capacity of introducing new and/or ameliorated products and/or processes. As innovation studies have increasingly more centrally recognised, investing in design can have an important effect on developing the firm's innovation capacity (see Moultrie and Livesey (2014) for a discussion). By allocating financial and non-financial resources to design activities firms can gain knowledge to become more capable of mastering the problems of industrial engineering entailed by devising new or marginally innovative products and/or processes (Walsh, 1996). Furthermore, through design investments firms could also become more sensitive to market demands or opportunities, and thus more prone to capture the need of new technological advancements (von Hippel, 1988). Quite interestingly, this holds true also with respect to service companies, whose design investments can increase a "softer" kind of innovations, like the marketing ones associated to their branding and/or re-branding efforts. The market repositioning that Dave knew in the UK digital TV market in the aftermath of a conspicuous design investment is an interesting illustrative example (Design Council, 2015).

Following these arguments and evidences, design investments have officially entered in a number of country-specific surveys on the intangible inputs that drive innovation (Awano et al., 2010) and evidence of that has been found for a large set of countries at the company level (Montresor and Vezzani, 2016). On this basis, following the literature on industrial design and combining it with innovation studies, we do expect that by investing in design the firm can acquire knowledge of both engineering and marketing nature, which increases its propensity of innovating in the product/process realm. Accordingly, we here (re)formulate a standard hypothesis that we expect to be (re)confirmed in our empirical application, by eventually proving its internal consistency:

Hp1: *Firms investing in design show a higher propensity to innovate.*

While apparently standard, the test of the previous hypothesis is required when the role of other design-related determinants of firm's innovation is accounted for. This holds particularly true for the results of a recent stream of studies, which have argued that an important innovation-driving role is played by the way in which design is conceived and actually managed within the firm. In this literature, most of the attention has been attracted by the role that designers have within the firm and by the firm's decision to keep design "in-house" rather than outsourcing the relative activities (e.g. Chiva and Alegre, 2007; von Stamm, 2008; Dell'Era and Verganti, 2010; Abecassis-Moedas and Berghozi, 2012; Filippetti and D'Ippolito, 2016). Rolls-Royce still represents an interesting example, of an innovation potential that also passes through the formal recognition of design among the "core engineering disciplines" of the company. In the same sector, the innovation profile of the already quoted case of Morgan Motor benefited from the establishment of a "digital design department" and of its integration with the ICT and the production ones. The integration of digital technologies and design can also contribute to the innovativeness of service firms, like the increase of commercial solutions experienced by on-line car-sharing platforms reveal (e.g. Uber and Liftshare).

In general, a higher innovation potential has been shown to accrue from firm's structures that are organised around an effective development of design and that use coordination mechanisms across their different departments to do so (Bruce et al., 1995; Perks, 2007; Roper et al., 2016). Following this stream of literature, and generalising its main insights, we expect that the firm's innovativeness also depends on the role design is given with respect to its other business activities. While hard to be synthesised, following the "ladder model" of design and its recent statistical operationalization (see Galindo-Rueda and Millot, 2015, p.27), this role can primarily vary in terms of design integration with other firm's activities. In particular, it can span from its potential neglect and/or the limited recognition of only one of its different functions (e.g. aesthetics), up to its integral use and central contribution to the firm's strategy. Conceptualizing the innovation process as systemic, and requiring firms to combine and "couple" different tangible and intangible knowledge inputs (Dosi, 1988), our expectation is that a progressively more "central" (i.e. integral) role of design - possibly in terms of management - would enable its more effective interaction and complementarity with other innovation drivers (e.g. R&D and ICT). Accordingly, we put forward our second hypothesis, which also represents an important element of control for our previous one to hold (Hp1):

Hp2: *An increasingly central role of design is associated with a higher firm's propensity to innovate.*

In considering the impact of design on firm performance, an additional aspect emerges with respect to the firm's capacity to innovate through design: its capacity of getting an economic return from its innovations; in brief, its innovation-related performance. While connected, innovativeness and innovation-related performance are two distinct aspects, which only partially overlap. This is an important point, which can be illustrated by drawing on the theoretical foundations of the seminal model by Crépon, Duguet and Mairesse (CDM) in innovation studies (Crepon et al., 2008). First of all, as the firm's innovative turnover is directly connected to "the use of innovations", rather

than to their "introduction", the role and the management of design are possibly more relevant than design investments for its unfolding. In the CDM model, this argument is developed with respect to productivity and to the need of other production/management activities than R&D investments, to transform the innovation output of R&D into a superior (productivity) performance. With respect to design, this is an argument to which business studies have pointed long since, even without passing through the role of innovation. In the early work by Roy and Riedel (1997), for example, commercially successful product development projects are associated to a specific "approach to design", rather than to a simple "attention to" (i.e. investment in) it, involving a "multidimensional focus" on "product performance, features and build quality, and [...] technical or design innovation" (p. 537). Similarly, Gemser and Leenders (2001) find that the impact of design on corporate performance depends on the degree of emergence and novelty of the firm's design strategy. More recently, Chiva and Alegre (2009) conclude that a "good design [in terms of corporate performance] does not emerge by chance or by simply investing in design, but rather as the result of a managed [design] process", where the reference is mainly to the construction of design management skills.

The role of design and of its management can be deemed crucial also by referring to our focal innovation-related firm performance, rather than to the firm performance in general. Indeed, this is an argument that can be supported by considering innovation and design within the framework of the firm's business model (Zott et al., 2011; Wirtz, 2011). As is well known, the role of the business model is also and above all that of "capturing value from innovation" (Chesbrough and Rosenbloom, 2002), that is, increasing the firm's capacity of bringing a new technology successfully to the market (e.g., Teece, 2010; Zott and Amit, 2010, 2007; Chesbrough, 2010). Accordingly, the impact of design on innovation-related firm performance passes through the role that the relative activities find within its business model. In specific terms, one should look at the extent at which design enters in the definition of the business model's components. In the case of the Italian design-made furniture company Kartell, for example, enabling new product meanings through design and technology is part of the firm's "value proposition" itself. In the same sector, design and technology are integral part of the firm's "value network" in the case of Luceplan (Dell'Era et al., 2008).

In more generic terms, and somehow extending the argument of our Hp2, we posit that the more "central" the position of design is within the firm, the more "embedded" design is in the business model, and the more design contributes to the typical role of the latter in creating value from innovation. In brief, the central position of design would allow the firm to take stock of its manifold dimensions (i.e. functional and aesthetic) in creating value from its innovations. Following this argument, we put forward our third hypothesis:

Hp3: *An increasingly central role of design within the firm is associated with a higher innovation-related performance.*

Keeping the attention on the firm's innovation-related performance, a different argument should be followed when considering design investments. Still according to the conceptual premises of the CDM model (Crepon et al., 2008), we argue that, like in the case of R&D for that model, "it is not innovation input [e.g. design investments] but

innovation output that increases [performance]" (p. 2, our amendment for design instead of R&D, and for performance instead of productivity). In other words, a performance impact of design could only follow from "the use of innovations in [the firm's] … activities" (ibidem, p.2), which design investments have helped the firm to obtain, working as an input. Extending this logic to our case, we claim that design investments as such do not directly affect the firm's economic performance, but rather indirectly, passing through the role that design has within the firm's business model. Accordingly, our expectation is that, by controlling for such a role, design investments should not emerge as significant in accounting for innovation-related performance, that is:

Hp4: *Once controlled for its role within the firm, investing in design is not associated with a higher innovation-related performance.*

Summing up, by crossing the distinction between investing in design and conceiving and placing design with the firm, with the distinction between firm's innovativeness and innovation-related performance, we ended out with four hypotheses. These hypotheses will be tested through the empirical application illustrated in the following section.

3. Empirical application

3.1 Data

Our empirical application is carried on a sample of more than 12,000 European firms from the last Flash Eurobarometer-415 on "The Innovation Trends at EU Enterprises": in brief, the Innobarometer 2014. In comparison to previous studies on the relationship between design and firm performance (see Section 2), the dimension of the sample is definitively larger and marked by a broader coverage in terms of countries, sectors, and firm sizes (European Commission, 2015). This is an important distinguishing feature of our application, which enables us to go beyond the simple ex-post rationalisation of the relationship at stake, obtainable from an exclusive focus on successful firms in terms of design. Indeed, taking into account the heterogeneity of the firms of such a large sample, results will enable us to reach general conclusions, with the potential of general, ex-ante predictions.

Like its previous waves, the Innobarometer 2014 is a "flash" survey, requiring some caution in the management of the data and in the interpretation of the responses (see Montresor et al., 2014). It is still a cross-sectional survey - containing information with respect to the period 2012-2014 - so that the econometric analyses of its data cannot be interpreted as more than significant correlations (in passing, this motivates the formulations of our own hypotheses).[2]

[2] The cross-sectional nature of the data retains us from inferring casual relationships and brings the standard problems of possible endogeneity of the regressors. However, the role of design within the firm - our focal variable - is likely to represent a firm's structural characteristics and indeed one that is likely not to suffer from contemporaneous correlations with its innovation performance.

Usually, the Innobarometer is also a quite focalised kind of survey, with limited opportunities of getting information outside the boundaries of the selected focal theme (e.g., in the Innobarometer 2013, that of the firm's intangibles), which would instead be crucial to build up control variables when testing relationships. The Innobarometer 2014 represents an interesting exception to this rule, as its focus is broader and includes questions on different aspects like: different typologies of innovation; innovation drivers, obstacles and performances; tangible and intangibles investments; specific highlights on both policy (e.g. innovative procurements) and company features, like that of interest for our study: the role of design within the firm.

In order to collect information on the above aspects, the Innobarometer 2014 has drawn a number of questions from previous surveys. This is for example the case of the "categorical" question on tangible and intangible investments - including design investments - taken and adapted from the previous Innobarometer 2013, in turn inspired by the NESTA intangible survey for the UK (see Montresor and Vezzani, 2016). Similarly, the questions on the firm's innovation outcomes and on its innovation-related performance are adapted from the Community Innovation Survey (CIS). Finally, with respect to the role of design – indeed our key info – the relative question has been built up by drawing on the so-called "ladder model". According to it, the role that design potentially plays within the firm can be ordered hierarchically from no design use, to more integrated and sophisticated uses in the firm: a model that has been implemented and tested by Statistics Denmark within its latest R&D and innovation surveys (for 2010 and 2012) (see Galindo-Rueda and Millot, 2015, p. 27). According to this latter model, the question on the role of design is based on the "open" definition approach typical of the Innobarometer survey, as opposed to the detailed instructions for definitions adopted by the CIS. An important benefit of this approach is that it does not impose a specific view on design (as well as on innovation) upon the respondents, which may perceive it differently according to the industry they operate, while the main cost is a lack of preciseness of the answers.

3.2 Econometric strategy and variables

Given our interest for the firm's innovativeness in the realm of new/ameliorated products and/or processes, and for its innovation-related performance, the focal variables of our empirical application are two. The first one is Innovation: a dummy that takes value 1 if the firm has introduced a new or improved product (i.e. good or service) and/or process, and 0 otherwise. Given the dichotomic nature of this variable, a suitable choice to test the two hypotheses related to this aspect (Hp1 and Hp4) is represented by the probit model:

$$\Pr(y_1 = 1|X) = \mathbf{\Phi}(x\beta_1)$$

where $\mathbf{\Phi}$ represents the standard cumulative normal distribution, x a set of variables and β_1 the relative coefficients.

The second dependent variable is represented by the firm's Innovative Turnover, expressed in classes, according to the share of turnover deriving from innovative products over the total turnover. In this case, an ordinal probit estimation represents

the natural choice for testing the relative set of hypotheses (Hp2 and Hp3). Accordingly, we can model the probability that the ordinal outcome y_2 of Innovative Turnover is equal to the value v_h as:

$$\Pr(y_2 = v_h) = \Pr(k_{h-1} < x\beta_2 + u_2 < k_h)$$

where for each firm, the probability of having innovative sales in the range identified by the outcome depends on the score falling between the cut-points k_{h-1} and k_h.

Given the structure of the questionnaire – innovative turnover is reported only by firms that have introduced a product innovation – our estimations might suffer from a problem of selection. That is, the errors determining whether our second dependent variable of interest is missing may be correlated with the errors determining the fact that a firm has introduced (or not) an innovation. In order to control for the selection process, we have first estimated our relationship using a standard Heckman procedure. The LR test for the independence of equations (covariance between the two error terms equal to zero) however suggests that a selection problem does not subsist with the adopted specification (chi2=1.50, p-val = 0.22). The probability of introducing an innovation and the related market performances can be modelled as two independent processes, which we estimate using a probit and an ordered probit model, respectively.

As far as the regressors of the two models above are concerned, we rely on the standard idea of knowledge production function in innovation studies (Griliches, 1986) and suppose that the firm's innovativeness and its related marketability are driven by a set of theoretically consistent variables, among which we plug those of our four focal hypotheses. First of all, in line with previous and related (i.e. Innobarometer-based) evidence on the role of intangibles for the firm's innovativeness - and about the different role of technological vs. non-technological intangibles - we consider two variables accounting for the firm's investments in each of the two intangibles categories. Following Montresor and Vezzani (2016), we build up the former (Technological Intangibles) by considering the average ratio of investments upon turnover declared by firms with respect to R&D and software, while we obtain the latter (Non-Technological Intangibles) by doing the same for investments in training and in organisation or business process improvements. In the same respect, and still due to data availability, we also look at the role of Tangible investments, with a dummy that refers to a positive incidence on the company turnover of the acquisition of machinery and equipment.

In addition to tangible and intangible investments, we also retain the explanatory role that the firm's adoption of organisational and marketing innovations can have, with the variable Non-Technological Innovation: a dummy that takes value 1 for those firms that have introduced one and/or both of the two. Considering this variable as explanatory of the firm's innovativeness and of its innovation-based performance could appear unjustified, given its usually retained "output", rather than "input" nature. Its inclusion is however consistent with two important sets of results in innovation and design studies (Romme, 2003;Veryzer, 2005). On the one hand, following a complementarity logic, product/process innovations have been found to benefit from the firm's propensity to engage in "complex innovation modes", in which

the upgrade of its knowledge-base is coupled and possibly facilitated by a change in its organisational practices and/or in its approach to the market (Evangelista and Vezzani, 2010; Filippetti, 2011). On the other hand, the value that the firm creates with its innovations has also turned out dependent on a set of changes in both its marketing and organisation realm, which are often required, side by side with design activities, by its successful use for innovating (Chiva and Roper et al., 2016; Alegre, 2007; Perks, 2007;Beverland, 2005; Gorb, 1990).

Coming to our focal regressors, in order to test Hp1 and Hp4, we refer to the variable Design Investments: a dummy taking value 1 if the firm reports, among the possible categories, a non-nil incidence of design investments on its turnover. In so doing, we capture a non-negligible role for them within the firm, rather than the simple presence of design investments. Hp2 and Hp3 are instead tested using the categories of the "ladder model", through which firms have been asked to "describe the business activities with regards to design", apart from the benchmark one ("Design is not used in the firm, it is not relevant"). These categories range from a Non-Systematic use of design, to a merely Aesthetic function, an Integral recognition of its manifold functionalities, up to a Central role for the firm's business activities. Of course, these items have a very limited informative value of the extent at which design is embedded in the firm's business model, to which the respondents have not been asked to refer in order to avoid the risk of systematic biases in its understanding. On the other hand, the same categories are at least suggestive of a way of conceiving the role of design within the firm, which could be retained non-independent from its management and positioning in the business model itself.

The list of independent variables is completed by a set of standard controls: the firm's age, captured through a dummy for Young firms (constituted after 1 January 2009); its size, retained by including other standard employment-classes than micro-ones (1-10 employees used as benchmark); its International status, a dummy for firms with non-nil turnover outside the country where the company is located; and its belonging to a Group, still captured with a dummy. Finally, we include a battery of sector and country fixed effects. Table 1 shows the descriptive statistics of the variables used in the empirical application.

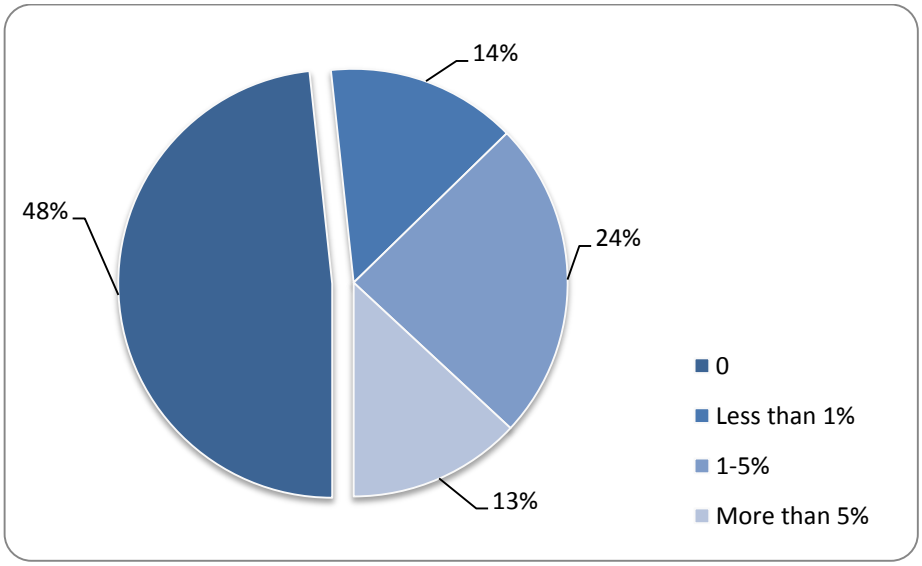
Table 1: Descriptive statistics

Innovative?	**0**	**1%-5%**	**6%-10%**	**11%-25%**	**26%-50%**	**51% or +**
Turnover	9.0%	24.4%	26.6%	23.2%	9.9%	7.0%
	Yes	**No**			**Mean**	**St.d dev.**
Young	88.5%	11.5%	Technological intangibles		2.02	0.77
Group	75.2%	24.8%	Non-Technological Intangibles		2.10	0.91
Innovation	32.3%	67.7%				
Non technological innovation	44.3%	55.7%				
International	66.9%	33.1%				
Tangible investments	21.9%	78.1%				
Employees	**1 to 9**	**10 to 49**	**50 to 249**	**250 to 499**	**500 or more**	
	44.7%	30.7%	17.7%	3.6%	3.3%	

4. Results

Before moving to the test of our hypotheses, it is interesting to see how the firms of the Innobarometer-2014 sample are characterised in terms of design. First of all, quite surprisingly, nearly half of the sampled firms declared not to have significantly invested in design in the relevant period (2012-2014) (Figure 1). Furthermore, for the other half of the sample, design investments are only moderate: the largest one is actually represented by firms for which the relevant share does not overcome 5% of the total turnover, with only 13% of the sample above this threshold. While somehow surprising, given the recognised importance of design for innovation in Europe, this evidence is in line with that found by recent surveys on intangibles. In the United Kingdom, for example, only approximately 10% of the 2010-survey companies declared to engage in design, although the percentage increases by focusing on the private sector and on services (Awano et al, 2010; Field and Franklin, 2012).

Figure 1 – Design investments as % of the firm's turnover



Source: Our calculations on Innobarometer 2014 data - **Note:** Sample shares (un-weighted)

When we consider the role of design within the firm, the picture appears even gloomier. About one third of the sampled firms declared not to make use of design and to consider it irrelevant for their business activities. The second largest share (20.8%) is made of firms considering design as integrated in their business activities. Only 14% of them regard design as central, nearly as much as those that make an exclusive aesthetic use of it (Table 2). Quite interestingly, the profile that emerges from considering the European scenario is different from that revealed by the first application of the ladder model to Denmark, as well as from some possibly successful case-studies (see Section 2). In the Danish case, the share of design users is even smaller (25% of the total), and with dissimilar modalities of use: 5%, with a sole aesthetic purpose, 10%, as integrated though not determining element, and 8% as central (Galindo-Rueda and Millot, 2015, p. 7).

Overall, the attention of European firms to design emerging from the Innobarometer 2014 appears quite modest and signals a certain gap in its innovative use, which the results of our analysis could possible help to address.

Table 2 - Which of the following statements best describes the activities of your company with regards to design?

Design is *not used* in the firm, it is not relevant	34.1%
The enterprise does *not work systematically* with design	17.7%
Design is used as last finish, enhancing the *appearance and attractiveness* of the final, developed product	13.4%
Design is an *integrated, although not directing element* of the development work in the firm	20.8%
Design is a *central and directing element* in the firm's strategy	14.1%

Source: Authors' calculations on Innobarometer 2014 data - **Note:** Sample shares (un-weighted)

Moving to the econometric estimates, the upper part of Table 3 reports the results of the correlation between design, in our twofold meaning, and firm's innovativeness (Column 1) and innovation-based performance (Column 2) for the entire Innobarometer sample. As we said, this sample encompasses both manufacturing and service firms, which have been argued to have a different approach to design and innovation. Indeed, some early innovation studies have shown that, relying on a standard Schumpeterian account of technological change, design is a relatively less important input for innovation in services than in manufacturing (Sirilli and Evangelista, 1988). Later on, however, with the take-off of an "autonomy" and, subsequently, of a "synthetic" approach to innovation in services (Coombs and Miles, 2000), the appreciation of their distinguishing features – like their perishable and intangible nature, the co-terminality of their production and consumption, and their information and organizational intensity – has led to recognise a relevant, though not standard innovation input role, of design for them. More recently, a case-study based approach to "design for services" has reinforced this insight, suggesting that the innovation impact of design in services could pass through the central recognition of its idiosyncratic role within the firm (business model): in particular, of its being "design for something" rather than "design something", "community-centred" rather than simply "user-centred", of "a full innovation strategy", rather than of "a single product" (Meroni and Sangiorgi, 2011).

Although we do not have a rich enough set of information to test for these specific arguments, in the following we will provide a disaggregated estimate of our model for manufacturing and services separately, in order to get at least some informative elements about their holding.

Starting with the full sample, before moving to the test of our four hypotheses, the results about the controls and the other non-focal regressors of the analysis are worthwhile commenting across the two columns of the lower part of Table 3.

Tab 3: Design, innovation and innovative turnover

	Innovation	Innovative Turnover
Design position		
Non-Systematic	0.166***	-0.005
	(0.039)	*(0.040)*
Aesthetic	0.265***	0.107**
	(0.047)	*(0.043)*
Integral	0.308***	0.189***
	(0.043)	*(0.038)*
Central	0.419***	0.291***
	(0.054)	*(0.044)*
Design investment	0.200***	-0.030
	(0.043)	*(0.039)*
Non-technological innovation	0.972***	0.166***
	(0.030)	*(0.030)*
Technological intangibles	0.291***	0.213***
	(0.025)	*(0.021)*
Non-Technological intangibles	0.216***	0.246***
	(0.027)	*(0.023)*
Tangible investments	0.180***	0.020
	(0.035)	*(0.036)*
Young	0.007	0.223***
	(0.044)	*(0.042)*
10 to 49 employees	-0.014	-0.087***
	(0.033)	*(0.032)*
50 to 249 employees	0.024	-0.226***
	(0.046)	*(0.040)*
250 to 499 employees	0.006	-0.356***
	(0.092)	*(0.071)*
500 or more employees	0.015	-0.285***
	(0.104)	*(0.075)*
Group	0.149***	0.021
	(0.039)	*(0.032)*
International (dummy)	0.145***	0.204***
	(0.033)	*(0.029)*
Sector fixed effects	*Included*	*Included*
Country fixed effects	*Included*	*Included*
Constant	-1.639***	
Cut-point 1		-0.042
Cut-point 2		0.966***
Cut-point 3		1.718***
Cut-point 4		2.497***
Cut-point 5		3.065***
Observations	11,862	6,719
Chi2	4342	1154
Psuedo R-squared	0.289	0.0516

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

First of all, when we look at the firm's propensity to innovate (Column 1), differently from previous studies in industrial organisation (e.g. Coad et al., 2016), younger firms

do not seem to gain a premium in terms of innovation, though they are not disadvantaged either. Furthermore, larger firms do not seem to have an advantage in introducing the innovations at stake, but smaller ones are not disadvantaged either. While somehow unexpected, this result could be due to the fact that the list of controls we include already capture innovation drivers related to the size of firms: in particular, Group, International and the different types of investments considered, which do have the expected sign, as we will show in the following.

On the other hand, the picture of the controls changes when we look at the innovation-based performance (Column 2). Younger firms now appear to have the advantage we did not observe in terms of "simple" innovation output: a result that consistently links with the role of age in negatively moderating the (growth) impact of innovation, rather than innovation per se (e.g. Coad et al, 2016). In the same respect, firm size is now negatively associated with the share of innovative turnover, possibly because larger firms spread the outcome of their innovative projects over a larger level of output. Belonging to a business group does not seem to provide here the advantages we found for the probability of introducing an innovation. This could be due to difficulties in diffusing, adapting and standardising innovations across different organisational units before reaching the market, which counterbalance the advantages discussed above. Finally, and as expected, given the chances of wider opportunities in (possibly more) competitive markets, not only have firms operating in different countries a higher probability of innovating, but they also tend to get extra return from them.

Interesting differences between innovativeness and innovation-based performance also emerge by looking at intangible and tangible investments. On the one hand, intangibles correlate positively with innovativeness (Column 1), irrespectively from their technological or non-technological nature, as in Montresor and Vezzani (2016); so do tangible investments, providing evidence of a "fully-augmented" knowledge-production function for our sample. On the other hand, while intangibles do also correlate with innovation performance (Column 2), tangibles do not, hinting that the economic returns from innovation might only pass through a "softer" kind of capital assets. The results of the two columns return to align when we consider the role of non-technological innovations: significant and positive in accounting for both of our dependent variables, as expected, according to our complementarity perspective.

When we finally get to the test of our four hypotheses, all of them appear supported. This provides us with a first general evidence of the consistency of our conceptual framework. More in particular, looking at Column 1 (Table 3), we find that, as expected and consistently, once controlled for other drivers, firms investing in design actually show a significantly higher probability of introducing an innovation, thus supporting our Hp1 about the role of design as innovation input. More interestingly, and providing more rigorous and extended support to the results of first empirical analysis (Galindo-Rueda and Millot, 2015), the coefficients attached to the variables capturing the role of design within the firm, are all positive and significant, including that related to an occasional use of design, confirming our Hp2 to a full extent. Even when it is not systematic, recognising an explicit role to design with the firm, and possibly carrying out its management accordingly, does seem to help firms innovating. What is more, still consistently with our hypothesis, the coefficients of the design-role

variables increase in size, moving up along the ladder of the retained categories: the more central design is, the more innovative the firm looks like. This is the first important result of our analysis, in two respects. On the one hand, from a methodological point of view, it reassures us about the validity of the ladder model of design, in front of the critics it has attracted for neglecting other conditions in the use of design than its degree of business integration (Galindo-Rueda and Millot, 2015, p. 27). On the other hand, from a conceptual point of view, having controlled for the role of design investments, the same result provides us with a genuine, although mainly suggestive, evidence about the role of design management in driving innovation.

When we look at the firm innovation-based performance (Column 2), our Hp3 gets confirmed, but somehow partially and conditionally. Indeed, the way design is conceived and positioned in the firm may affect its innovative turnover, but providing this is not occasional: the non-systematic use category is actually the only one to be not significant. In other words, a non-systematic use of design does not make any difference, in economic terms, with respect to not using it at all for the sake of innovation marketability. This is a second important result about the way design should be perceived and possibly managed within the firm. Resorting occasionally to it, possibly on a spot-like basis, as it if were at the periphery of the business model, actually vanishes the role it could potentially have in helping the firm benefiting from innovation, precisely like if it were absent. A related important result concerns the importance that an increasing prominence of design within the firm could have for its innovative turnover. More precisely, while firms get a higher premium by adopting an integral than a purely aesthetic approach to design, a central role of design, possibly associated to its centrality in the firm's business model, is the alternative that pays the most in terms of returns from innovation.

The fourth and final result of the empirical application is also relevant. Consistently with our Hp4, once accounting for the role of design within the firm, design investments are not associated with a higher innovative turnover: the relative coefficient is not statistically significant. On the one hand, and still methodologically, this result suggests that the indirect performance (i.e. productivity) impact that the CDM model (Crepon et al., 1998) has envisaged for R&D does also apply to design investments, and possibly to other intangible investments. On the other hand, from a conceptual point of view, having controlled for the role of design within the firm, investing in design does not appear to be a leverage for gaining from innovation, and should not be used as such.

Overall, the previous results seem to reassure us about the consistency of our conceptual framework and hypotheses. In spite of interesting differentiations, further confirmation elements emerge from the separated estimates of our model for manufacturing and service firms, respectively. First of all, when we look at the firm's innovativeness (Table 4), Hp1 gets confirmed across both the two industries. However, as expected, the role of design as an innovation input appears weaker for services than for manufacturing: the relative coefficient is statistically less significant and smaller in size. This is a confirmed peculiarity of the "softer" nature of product innovation in services (Sirilli and Evangelista, 1998), which is reinforced by the exclusive significance of non-technological intangibles in accounting for their

innovation: a result already found in previous studies using Innobarometer data (Montresor and Vezzani, 2016).

Tab 4: Design and innovation, manufacturing vs. services

	Manufacturing	Services
Design position		
Non-Systematic	0.216**	0.083
	(0.094)	*(0.071)*
Aesthetic	0.269**	0.204**
	(0.106)	*(0.084)*
Integral	0.270***	0.235***
	(0.096)	*(0.076)*
Central	0.487***	0.313***
	(0.114)	*(0.092)*
Design investment	0.319***	0.137*
	(0.100)	*(0.076)*
Non-technological innovation	0.915***	0.972***
	(0.069)	*(0.053)*
Technological intangibles	0.344***	0.302***
	(0.056)	*(0.041)*
Non-Technological intangibles	0.082	0.302***
	(0.064)	*(0.048)*
Tangible investments	0.231***	0.196***
	(0.083)	*(0.061)*
Young	0.001	0.022
	(0.122)	*(0.074)*
10 to 49 employees	0.029	0.035
	(0.082)	*(0.061)*
50 to 249 employees	0.175*	0.057
	(0.105)	*(0.081)*
250 to 499 employees	-0.011	0.268
	(0.166)	*(0.171)*
500 or more employees	0.393*	-0.095
	(0.218)	*(0.153)*
Group	0.002	0.177***
	(0.086)	*(0.067)*
International (dummy)	0.105	0.109*
	(0.071)	*(0.057)*
Constant	-1.532***	-1.969***
	(0.214)	*(0.159)*
Country fixed effects	*Included*	*Included*
Observations	2,540	3,876
Chi2	768	1561
Psuedo R-squared	0.275	0.317

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

Tab 5: Design and innovative turnover, manufacturing vs. services

	Manufacturing	Services
Design position		
Non-Systematic	0.067	-0.046
	(0.092)	*(0.072)*
Aesthetic	0.190**	-0.028
	(0.092)	*(0.076)*
Integral	0.275***	0.102
	(0.084)	*(0.068)*
Central	0.492***	0.203***
	(0.093)	*(0.077)*
Design investment	-0.001	-0.033
	(0.085)	*(0.070)*
Non-technological innovation	0.189***	0.187***
	(0.062)	*(0.053)*
Technological intangibles	0.220***	0.238***
	(0.045)	*(0.035)*
Non-Technological intangibles	0.254***	0.207***
	(0.047)	*(0.040)*
Tangible investments	0.076	0.027
	(0.083)	*(0.063)*
Young	0.316***	0.263***
	(0.105)	*(0.069)*
10 to 49 employees	-0.125*	-0.098*
	(0.074)	*(0.055)*
50 to 249 employees	-0.198**	-0.248***
	(0.084)	*(0.068)*
250 to 499 employees	-0.502***	-0.252**
	(0.125)	*(0.120)*
500 or more employees	-0.308**	-0.299**
	(0.136)	*(0.119)*
Group	0.026	-0.028
	(0.066)	*(0.054)*
International (dummy)	0.235***	0.272***
	(0.060)	*(0.049)*
Cut-point 1	0.151	0.092
	(0.186)	*(0.159)*
Cut-point 2	1.255***	1.021***
	(0.188)	*(0.160)*
Cut-point 3	2.105***	1.755***
	(0.190)	*(0.162)*
Cut-point 4	2.989***	2.498***
	(0.194)	*(0.164)*
Cut-point 5	3.634***	3.065***
	(0.199)	*(0.167)*
Country fixed effects	*Included*	*Included*
Observations	1,619	2,211
Chi2	330.8	423
Psuedo R-squared	0.0633	0.0563

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

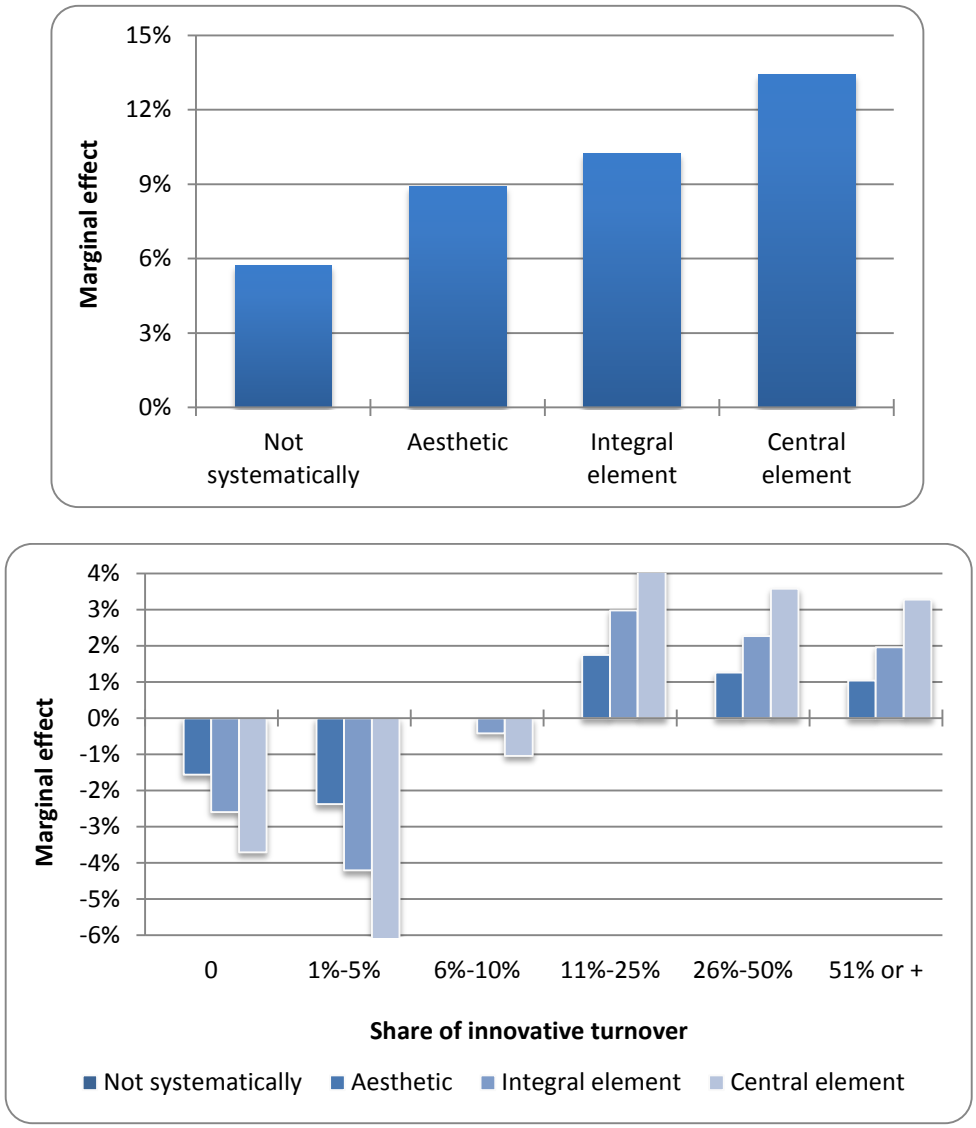
In general terms, also our Hp2 gets confirmed both in manufacturing and in services, but with an important specification. Manufacturing firms keep on showing a significant correlation between innovation and any kind of design position within them, even with an occasional one. On the other hand, service firms apparently need to be more "selective" in their innovation management of design, as a non-systematic use of it does not pay off. This is an interesting specification of our general result, along with that of the smaller coefficients of each and every of the considered design positions for services. In both industries, however, the coefficients still increase by moving up along the design ladder.

When we look at the hypotheses on design and innovation-based performance our general results get still confirmed, but with further interesting differentiations (Table 5). The most relevant peculiarity, and indeed the most important result of disaggregating the estimates between manufacturing and services, concerns Hp3. Manufacturing firms confirm the importance of moving from an occasional to at least a systematic role of design in order to extend its impact from that on innovativeness to that on innovation "marketability". On the contrary, the innovative-turnover of services firms appears significantly associated only with the most central of the design positions within the firm. Quite interestingly, and somehow corroborating the emerging literature on design for services, it is only when design is set at the core of the firm's business model - and its idiosyncratic features are thus presumably recognised and managed consistently - that a design-driven innovation actually translates into a higher economic performance. Differently, both in manufacturing and services, when controlling for the role of design within the firm design investments do not appear significantly correlated with its innovation-based performance, providing further support to our last Hp4.

Turning back to the whole sample of firms, additional insights about the results we obtained emerge when we look at the marginal effects (Figure 2) of the role of design within the firm on the firm's innovativeness – in the lower panel - and on its innovation-related performance – in the upper panel. First of all, the alleged role of design management in driving the firm's innovativeness is definitively non-trivial. Retaining design as a central element in the firm's activities increases the probability to innovate of more than 10% with respect to not using it at all, with an irregular progression in passing across the intermediate categories, and with the largest gains accruing from non-systematically to aesthetic, and from integral to central.

Looking at the innovation-based performance, a "systematic" approach to design sharply decreases the probability that a firm gets null or low (between 1 and 5 percent of their turnover) returns from its innovations. This is particularly true when design is considered as a central element, as in this case the probability of belonging to one of the two groups decrease by 3.7 and 6.5 percentage points, respectively.

Fig 2: Marginal effect of design position on the probability to innovate (up) and on innovative returns (down)



The role that design can play in innovating successfully is also evident when considering the probability of having high shares of innovative turnover (the three classes on the right part of the bottom panel). In particular, firms in which design plays a Central role have a probability of 3.3 percentage points higher to get the majority of their turnover from innovative products. The probability premium of a central design is the highest – more than 4 percentage points – for the firm's capacity of getting more than one fourth of its turnover from its innovations. All in all, also this latter marginal effect appears considerable, although still possibly less evident than in previous applications of the same conceptual framework.

5. Conclusions

After more than two decays of intensive research, the impact of design on firm performance appears nowadays nearly unquestionable and only debatable in size. However, the way such an impact actually manifests and can accordingly be increased is still a "black-box", which requires further inspection. This is particularly so when the role of innovation in the same relationship is considered, by referring to the economic returns firms can get from the use of design in introducing their innovations.

Bridging innovation studies with a still fluid stream of research work on design, we have argued that the design-innovation-performance relationship is manifold and should be disentangled accordingly. First of all, design investments should be considered as an innovation input, "not exclusive, but exclusively". On the one hand, their role of innovation-driver is not exclusive, as it can also be played by the position design is recognised with the firm: possibly through its choices of design management with respect to the cogent business model. On the other hand, design investments should be retained an innovation input exclusively, with no other direct impact on the firm's capacity of bringing successfully its innovations on the market. Indeed, this is arguably an exclusive property of the integration of design with other business activities: still through its possible embodiment in the firm's business model.

We have also added systematic evidence to a field of investigation that still mainly rely on case-studies. Our arguments have been tested on a large sample of firms, marked by sufficient heterogeneity to go beyond the typical ex-post rationalisations of 'design using, winning firms'. In particular, we have exploited the advantages of the Innobarometer 2014 survey in the collection of design-related information for a large sample of innovative and non-innovative firms. This has permitted us to take into account differences between these two groups of firms in their propensity to innovate and to assess the role of design in guaranteeing successful performances of innovative firms. Furthermore, the wide coverage of the same dataset has also allowed us to investigate the extent at which our research hypotheses differentiate by distinguishing manufacturing from service firms. As we said, reinforcing the opportunity of an autonomy, if not even of a synthetic approach to innovation in services, design plays a less significant role of innovation input with respect to manufacturing. On the other hand, service firms need to be more selective in the position they recognise to design within the firm, and set is as central for the relative innovations to increase their economic performances.

In spite of these and other specifications, the results we obtained are generally supportive of our conceptual arguments and quite rich of implications. In terms of academic research, we have contributed to increase the convergence between two disciplines, innovation economics and design studies, which have up to now unfortunately navigate in parallel making one only an occasional and superficial use of the other. By combining the two fields more extensively, we have contributed to: i) the economic investigation of the determinants of firm's innovation, by including design management among them and by considering the role of design investments among its drivers; ii) the strategic analysis of design, by unravelling the role of its position and management in allowing firms to capture the value of their innovations.

As far as the implications of the results are concerned, the problem of "sizing" design within the firm in terms of resources and investments should be considered only a part of the firm's innovation strategy. Design investments do not guarantee innovation returns per se, while positioning design in the firm, and possibly in their business model, does it: in brief, managing design is crucial to successfully bring new technologies on the market. A related recommendation is that of giving design a central role within the firm in order to innovate successfully, especially when this is a service company, by making design systematically used and integrated with the other business activities. Dealing with design "occasionally" might increase the firm's innovativeness (though less than making it centrally), but it does not increase the returns from it. In other words, when it is conceived as peripheral, and possibly out of the firm business model, design for innovation does not pay off. Finally, it should be considered that design is part of a "complex" innovation mode, being interlinked with other factors like tangible/intangible investments and non-technological innovations, which possibly require an as much complex business model to support its value creation.

The present study is of course not free from limitations, among which two are more urgent to overcome with more refined, but still unavailable data and future research. As we said, the ladder model of design is only a first and very distant indication of the role of design within the firm's business model. More detailed information would be needed in future to capture it, keeping in mind the risks of getting detailed information only for a limited number of firms and the possible systematic response biases it would entail. Secondly, the hypotheses we have tested about design and innovation refer to cross-sectional data and do represent conditional correlations. An even more substantial effort would be required to measure design and its role in innovation towards the collection of longitudinal data. This would allow to getting closer to an actual impact of design on innovation and on the related economic performance. On the other hand, in attenuating this limitation of our application, it should be considered that the role of design with the firm - our focal regressor - is possibly one of its structural characteristics, and indeed one that is likely not to suffer from contemporaneous correlations with its innovation performance.

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