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DETERMINANTS OF SILENT AND EXPLICIT INDUSTRIAL DESIGN

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A B S T R A C T
This paper investigates the relationship between the use of silent or explicit design (SD or ED) and the characteristics of firms or sectors that use each of these types of design in Argentina. The findings show that SD differs from ED and that the differences have important implications for the creation of policies to support competitiveness as well as for the development of business strategies. The study contributes to the literature by identifying three groups of dimensions. (1) Structural. Neither size nor barriers to the use of design bear relation to the use of design. (2) Dynamic. SD and ED have different effects on competitiveness based on the different links each type of design has with knowledge (particularly absorptive capacity and knowledge of new technology). (3) Technological intensity. Sectors with low technological intensity are identified as high-design intensity sectors, linked to the use of new technologies coming from others sectors.

1. Introduction

Economic changes due to globalization have intensified global competition. This heightened competition has increased companies' knowledge of products and production processes and has led to organizational changes (Bianchi & Labory, 2011). In this context, knowledge-intensive business services (KIBS) are particularly important. Design, a prime example of KIBS, has a bearing on technological and nontechnological innovations because of its importance in R&D (Tether, 2009; Walsh, 1996). Design is also important because of its link to product differentiation and the development of innovations (Czarnitzki & Thorwarth, 2012; Talke, Salomo, Wieringa, & Lutz, 2009). Design is a vital strategic resource for firms (Walsh & Roy, 1985). It brings together contributions from numerous fields besides aesthetics. Such fields include ergonomics, production efficiency, and the incorporation of new technologies and components (Walsh, 1996). Design creates value that transcends mere form and function.

This value is linked to what the product is able to express through the holistic properties of its design (Kumar & Noble, 2016).
This study focuses on industrial (product) design, defined as the activity of designing or redesigning products. Like Ravasi, Marcotti, and Stigliani (2008), we exclude design activities linked to brand image, graphics, commercial furniture, and packaging. All firms perform some type of industrial design activity (Walsh, 1996), although this activity is not always performed by professional designers (Tether, 2005b). Gorb and Dumas (1987) labeled such activities as silent design (SD) and labeled design by professional designers as explicit design (ED).
This study contributes to our understanding of the differences in firm and sector characteristics in terms of degree of professionalization in design use. Scholars have generally studied design by focusing exclusively on design by professionals. The present study enhances our understanding of design use by establishing a distinction between two types of design: silent design (SD) and explicit design (ED). We also distinguish these two types of design from the non-use of design. This study emphasizes the idea that SD and ED differ and that these differences have major implications for public policies designed to promote competitiveness and for managers seeking to establish business strategies.
The literature on SMEs shows that businesses use design more tan they use R&D (Tether, 2005a). The literature also shows that design is important for technological and non-technological innovations in R&Dintensive sectors and traditional sectors with a non-technological base. Design is relevant for differentiation strategies and cost-focused strategies, allowing firms to access to new markets and cement their presence in mature markets (Gemser & Leenders, 2001).
Thus, given the importance of the use of design, this study identifies the determinants of design use in industrial firms and explores differences in the characteristics of firms that use SD or ED in Argentina. Multinomial regression was used to analyze the empirical data.
The study's main contributions are the identification and characterization of SD and ED. The study's findings are also novel. Despite discussing the concept of SD, scholars have never performed an empirical study of SD because of the difficulty in capturing data on SDrelated activities. The present study contributes to the literature by identifying three groups of dimensions related to the use of design: structural dimensions (related to size and barriers to use of design, particularly financial), dynamic dimensions (related to knowledge, use of new technologies, and relationships with firms in foreign markets), and dimensions related to the technological intensity within the sector.
The paper has the following structure: Section 2 presents a review of the empirical and theoretical studies used to develop the research hypotheses. Section 3 describes the data and method. Section 4 presents the results. Section 5 discusses the findings. Finally, Section 6 presents the conclusions, implications, limitations, and opportunities for future research.

2. Literature review and hypotheses

Design is increasingly viewed as a vital strategic resource for firms (Dell'Era, Marchesi, & Verganti, 2010). Firms that are oriented toward good design do not compete on price and can actually sell their products at a higher price than competitors can (Walsh & Roy, 1985). Design is used by firms with strategies

focused on product differentiation as well as firms with cost-focused strategies. In many industries, new products are highly similar in terms of functionality but differ in their design (Talke et al., 2009). Therefore, product design offers a major opportunity to achieve a sustainable competitive advantage (Hertenstein, Platt, & Veryzer, 2005) in emerging or high-technology markets or in mature markets (Gemser & Leenders, 2001). From a dynamic perspective, successful firms are said to be those that continually modify and adapt their designs in response to the emergence of new technologies, new products, and changes in demand (Walsh, 1996).

The philosophy of design (principles of design and style) mediates the relationship between the firm's strategy, key capabilities, and Brand image (Ravasi & Lojacono, 2005). Design is important within a radical innovation business strategy (Verganti, 2008), as well as in cases of incremental innovation, because it allows firms to compete by having a differentiated product, better efficiency in the use of materials, and the ability to redesign products to aid production (Walsh, 1996).

Design is fundamental for a system of production for several reasons.It reduces production costs by increasing overall efficiency in the production process (Hertenstein et al., 2005; Potter et al., 1991), has a positive association with labor productivity and greater total factor productivity (Haskel et al., 2005), improves financial efficiency (Hertenstein et al., 2005), and enables access to new markets and encourages import substitution (Potter et al., 1991).

The value that design can add to innovation means that design can act as a complementary asset and encourage the appropriation of returns from innovation (Tether, 2005b). This link between design and innovation explains why, despite having numerous competitors, some firms is able to become sector leaders and capture a large market share. The remainder of this section summarizes several factors discussed in the literature that explain firms' use of design services.

2.1. Size of firms and resource availability

Efficient access to KIBS may be a factor of competitiveness, particularly among SMEs (Viljamaa, 2011). KIBS make a crucial contribution to SMEs because SMEs have limited internal financial, staffing, and capability resources (Muller & Zenker, 2001; Viljamaa, 2011). Thus, a lack of resources rather than a lack of interest (Walsh & Roy, 1985) explains the limited investment in design. Regardless of size and limited resources, however, many firms that focus on innovation-driven design become world leaders (Verganti, 2008), so the way design spend affects innovation performance does not differ across different-sized firms (Marsili & Salter, 2006).

In SMEs, innovations are incremental and focus primarily on design (OECD, 2000; Walsh, 1996). Therefore, SMEs do not necessarily require the use of scientific or sophisticated engineering knowledge. Design activities are more common than R&D activities because design is a cheaper, more convenient way of innovating than R&D is (Verganti, 2008; Walsh, 1996). This situation is especially true of smaller firms (OECD, 2000; Tether, 2005a). The decision by SMEs to adopt a designbased strategy rather than a strategy based on R&D is partially because of their size and availability of resources (Freeman, 1982). Accordingly, KIBS such as industry design services are important because they enable firms to gather specialized knowledge (Viljamaa, 2011).

Other barriers to the use of design, particularly in SMEs, relate to poor design experience, a lack of design expectations, and a lack of knowledge regarding where to seek design professionals (European Commission, 2009; von Stamm, 1998). Therefore, SMEs often informally develop their own design activities, whereas larger firms use ED (Tether, 2009).

H1. Firm size influences the type of industrial design.

H2. Resource availability influences the type of industrial design.

2.2. Knowledge and services of industrial design

Knowledge is one of the principal factors that affect the feasibility of design activities. Knowledge is a fundamental resource of the firm, and it must be addressed and effectively exploited from a dynamic perspective of the firm's capabilities (Zollo & Winter, 2002) to obtain sustainable competitive advantages (Piccoli & Ives, 2005) and accumulate intangible assets (Denford, 2013). This dynamic perspective of the firm's capabilities depends on previously accumulated knowledge and involves the ability to combine internal and external knowledge sources.

The key characteristics of knowledge (transfer, aggregation, and appropriation) (Grant, 1996) and its tacit and explicit nature (Polanyi, 1966) have major implications in the way people's activities should be organized to achieve maximum benefit. The possibility of accumulating knowledge depends on the firm's knowledge base, with a large knowledge base implying a greater possibility of absorbing new knowledge. In other words, the possibility of transferring, aggregating, and appropriating new knowledge is greater when the firm already has knowledge on a particular topic (Balogun & Jenkins, 2003). Thus, a firm's knowledge can grow through the absorption of knowledge that already exists externally (Nickerson & Zenger, 2004).

In design, where a great deal of knowledge is tacit (Tether, 2005a), the role of the designer as a translator and intermediary or disseminator of knowledge helps knowledge absorption. Therefore, the existence of design knowledge within the firm helps the absorption of new design know-how (von Stamm, 1998).

H3. Knowledge absorptive capacity influences the type of industrial design service.

2.3. New technologies and internationalization

Regardless of the technological intensity of the sector, face-to-face relationships between designer and firm continue to be operationally strategic and necessary. Nevertheless, the rapid development of communication technologies obliges the firm to embrace these technologies (Vanchan, 2007). In the design co-production process, good communication and information flow between people involved in design itself and people from other related areas (production, concept, and brand) are essential. Therefore, greater knowledge content in production processes drives growth in the use of industry design services through technological change and the introduction of new ICTs (Gotsch, Hipp, Gallego & Rubalcaba, 2011).

Designers can contribute to innovation development in at least two ways. The first way is specific to the field of design and relates to the designers' language and creative message (ICSID, 2013), which can lead to radical redefinitions of the product's meaning (innovations driven by design) (Verganti, 2008). The second way derives from the designer's knowledge of new technologies in the processes, machinery and equipment, and materials that are deployed during design and innovation.

Firms that are more internationalized make more intense use of design, particularly ED (Tether, 2009). Design plays a central role in accessing international markets (Rusten, 1997; Verganti, 2008). Likewise, greater exposure in the domestic market to foreign competitors relates to a greater use of design (Tether, 2009; Verganti, 2008).

Thus, design adds value, which helps firms enter markets, particularly markets where firms are exposed to international competition (Verganti, 2008). Verganti reported that greater use of design by industrial firms than by service firms can be explained because the industrial sector manufactures tangible products that are freely internationally importable and exportable and therefore have greater exposure abroad. Thus, firms that are more internationalized make more intensive use of design (Haskel et al., 2005; Tether, 2009).

H4. Knowledge of new technologies influences the type of industrial design.

H5. The exposure of companies to international competition influences the type of industrial design.

2.4. Technological intensity within the sector

R&D-intensive sectors, traditional non-technology-based sectors (Walsh, 1996), emerging or high-tech markets, and mature markets (Gemser & Leenders, 2001) all use design. Some industrial sectors study design activities in greater depth given the strategic role of design. Scholars have analyzed design innovations in the automotive sector (Talke et al., 2009), fashion industry (McRobbie, 1998), furniture industry (Rusten, 1997), and ceramics sector (Chiva & Alegre, 2007).

Design expenditure is high in high-R&D industries such as the aerospace and automotive industries. However, the use of design is proportionately more widespread in sectors with low technological intensity (textiles, clothing, and furniture) than in those with high technological intensity (Tether, 2005a). This difference in design use is because of the combination of greater relative opportunity for nontechnological innovation and the need to maintain and strengthen market credibility (Tether, 2005b). Therefore, design is important in both R&D-intensive sectors and traditional non-technology-based sectors (Walsh, 1996).

Tether (2009) also studied variables related to new knowledge and ICTs and examined the technological level of the firm, measured in terms of acquisition of hardware and software. Walsh (1996) reported a relationship between new technologies and design.

H6. The technological intensity of the sector influences the type of industrial design.

3. Data and method

The data were gathered from the 2010 Structural Survey on SMEs by the SME Observatory Foundation of Argentina (Fundación Observatorio PYME de Argentina). The survey covered SMEs whose activity is manufacturing (10–200 employees). We analyzed data on 922 Argentinian SMEs.

The 2010 structural survey on SMEs identifies two ways to approach design:

1. To hire design professionals or quasi-professionals (here, ED);
2. To perform design activities that do not require the employment of design professionals or quasi-professionals (here, SD).

Of the 922 companies under study, 421 performed ED or SD, and the remaining 501 had no design activities. Multinomial logistic regression analysis was employed with a three-value dependent variable: 0 when the company used no design services, 1 when the company hired design professionals or quasi-professionals, and 2 when the company employed silent design. All independent variables were dummy variables.

The model was validated using the likelihood ratio (LR) and Wald tests. Huber (1967) and White (1980) developed the process for these tests. The process yielded a covariance matrix for the unbiased estimator. This matrix was robust with respect to heteroscedasticity and autocorrelation (Fritsch & Falck, 2010). After revising the results of both tests for the first version of the model, we eliminated three variables that did not contribute to the model ($p >= 0.20$).

Industrial activities were classified according to the International Standard Industrial Classification (ISIC). Sectors were classified according to the OECD classification of technological intensity (Tether, 2009). Following Czarnitzki and Thorwarth (2012) and Tether (2009), we grouped different sectors into a single variable.

Firm size has been widely used in innovation studies (Marsili & Salter, 2006). For example, Czarnitzki and Thorwarth (2012) and Marsili and Salter (2006) used number of employees as an explanatory variable. Tether (2009) also used number of employees to study design activities (explicit, hidden, and non-design). Number of employees enables control of elements linked to economies of scale (Czarnitzki & Thorwarth, 2012). Like Mate-Sanchez-Val and Harris (2014), we used the number of employees to define firm size. (See Table 1).

The relationship between industrial design and performance is linked directly and positively to financial issues (Candi & Gemser, 2010). Therefore, financing is another important design-related dimensión (Hertenstein et al., 2005; Kleinknecht, 1989; Walsh & Roy, 1985). In addition, problems to finance design activities are envisaged for small firms (Walsh & Roy, 1985), which means that a lack of financing becomes a barrier to design use. These elements are analyzed using indicators related to access to financing. Such indicators include self-financing and bank financing of investments and rejected bank loan applications.

Table 1
Description of the independent variables.

Variable	Description
Number of employees	1 if the firm had > 50 employees; 0 if it had between 6 and 50 employees
Self-financing investments	1 if 20% or more of the investments were financed using own funds; 0 if 0–20% were financed using own resources
Bank credit for investments	1 if 20% or more of investments were financed using bank credit; 0 if 0–20% were financed using bank credit
Rejected applications for bank loans	1 if the firm had a loan application rejected (excluding overdraft) in the last year; 0 if no application was rejected
Demand for university graduates	1 if the firm had demand for university graduates; 0 if not
Internal network (LAN-WiFi)	1 if the firm had an internal network; 0 if not
Mobile data service	1 if the firm used mobile data; 0 if not
Exports	1 if the firm exported in 2010; 0 if not
Domestic market share loss to imports	1 if the firm had lost market share to imports in the last year; 0 if not
Technological intensity	1 if low; 0 if medium or high

Table 2
Support in the literature for dimensions and explanatory variables.

Dimensions	Independent variables	Supporting literature	Type of study	
Size of firm	Number of employees	Czarnitzki & Thorwarth, 2012	Empirical	Quantitative
		Haskel et al., 2005	Empirical	Quantitative
		Tether, 2009	Empirical	Quantitative
Availability of resources (barrier to design)	Problems with financing	Hertenstein et al., 2005	Empirical	Quantitative
	Self-financing	Kleinknecht, 1989	Empirical	Quantitative
	Bank credit	Walsh & Roy, 1985	Empirical	Qualitative
Absorptive capacity	Professionalization	Kleinknecht, 1989	Empirical	Quantitative
	Demand for university graduates	Mate-Sanchez-Val & Harris, 2014	Empirical	Quantitative
		Tether, 2009	Empirical	Quantitative
		von Stamm, 1998	Empirical	Qualitative
Technological level of firm	Use of new communications technologies	Tether, 2009; Francis and Winstanley (1988)	Empirical	Quantitative
		Walsh, 1996	Theoretical	–
Exposure to international competition	Exposure to imports	Potter et al., 1991	Empirical	Quantitative
	Production destined for foreign markets	Haskel et al. (2005)	Empirical	Quantitative
		Tether, 2009	Empirical	Quantitative
		Walsh & Roy, 1985	Empirical	Qualitative
Sector	Technological level of sector	Tether, 2005a	Empirical	Quantitative
		Vanchan, 2007	Empirical	Quantitative

Tether (2009) used training as a proxy for absorptive capacity in models of design use. Kleinknecht (1989) linked absorptive capacity to barriers to innovation and linked them to the lack of qualified management and difficulty in finding qualified personnel (See Table 2). Consequently, employee qualification is an important variable for explaining differences in absorptive capacity. We proxied employee qualification using recruitment of university graduates in design.

Haskel et al. (2005) included a variable in their model to identify exporting firms. They found that greater export orientation and larger size relate to greater design expenditure. Walsh and Roy (1985) explained firm performance in terms of the relationship between exports and design.

We included an additional variable to capture the relationship between design services and import threats. Potter et al. (1991) reported a positive effect of design on import substitution. In contrast, Tether (2009) found that firms that were linked to the national market were greater users of ED than firms linked to the local market.

Czarnitzki and Thorwarth (2012) and Tether (2009) also included the dimension of industrial sector in their models, grouping several sectors into one variable. Tether (2005a) analyzed the design and R&D spending of firms and grouped industrial sectors according to technological intensity. Table 3 presents the definition of each variable.

4. Results

We analyzed how the six conceptual dimensions presented in the previous section affect the use of design. Each dimension comprised one or more variables.

After applying the Wald and LR tests, we selected the explanatory variables. The pseudo R2 value was 0.12. This value was sufficient because, in multinomial logistic regression, this value yields only an approximation of goodness of fit. Pseudo R2 is not fully analogous to R2 in ordinary least squares (Hu, Shao, & Palta, 2006a, 2006b). The joint significance test (LR, 2 א) yielded a value of 130.45, with a probability of 0.00 for the statistic 2 א. The model had a high predictive capacity. Therefore, overall, the model was robust and consistent and offered acceptable predictions.

Use of design was the dependent variable in the multinomial logistic regression. Using non-use of design as a baseline yielded the coefficients that explain the use of ED and SD in comparison to the non-use of design. Taking use of SD as a baseline yielded the coefficients that explain the use of ED in relation to the use of SD. The regression coefficients and the significance of these coefficients appear in Table 4.

The size of the firm (H1) was a significant feature of firms with SD compared with firms that did not use design services. The relationship between the use of SD and the size of the firm was inverted. Larger firms were less likely to use SD, whereas smaller firms tended to use SD. No differences were identified between the size of firms that used ED and the size of firms that used SD, nor between the size of firms that used ED and the size of firms that did not use design.

In relation to resource availability (H2), no significant differences between ED and SD were identified. However, the capacity to self-finance investments was a significant variable that explained the use of ED and the use of SD (in relation to non-use). The analysis also identified a relationship between firms with rejected bank loan applications and SD. Thus, SD was associated not only with smaller firms, but also with firms that had greater financial restrictions.

Table 3
Definition of explanatory variables.

Dimension	Independent variable	Definition
Size of firm	Number of employees	According to the National Institute for Statistics and Censuses (INDEC, 2005), occupied persons are persons who work whether or not they are paid.
Availability of resources (barrier to design)	Self-financing investments	Whether in 2010 the firm financed part of its investments using its own capital
	Bank financing of investments	Whether in 2010 the firm's investments were financed at least partially by bank credit
	Rejection of request for bank loans	Whether the firm had a bank loan application rejected in the last year (excluding overdraft)
Absorptive capacity	University demand	Whether the firm sought university graduates to cover vacancies
Tech level of firm	Internal network (LAN-WiFi)	Whether the firm had a LAN to share data
	Mobile data service	Whether the firm had a mobile data service
Exposure to international competition	Exports	Whether the firm exported in 2010
	Domestic market loss to imports	Whether the firm's market share has fallen because of imports in the last year
Sector	Tech level in sector	Technological intensity according to OECD (2011) categories

Table 4
Determinants of the use of design services.

Hypothesis	Variables	Explicit use vs. non-use design coefficient		Silent use vs. non-use design coefficient		Explicit use vs. silent use coefficient	
H1	Number of employees	− 0.010		− 0.334	*	0.324	
H2	Self-financing of investments	0.713	***	0.498	***	0.214	
	Bank financing of investments	− 0.218		− 0.242		0.024	
	Rejected applications for bank loans	0.089		0.683	**	− 0.593	
H3	Demand for university graduates	1.015	***	0.269		0.746	***
H4	Use of internal networks (Lan-WiFi)	1.051	***	0.041		1.011	***
	Use of mobile data	0.613	***	0.667	***	− 0.054	
H5	Domestic market loss to imports	0.554	**	0.599	***	− 0.045	
	Export orientation	0.698	***	0.257		0.441	*
H6	Low technological intensity	0.550	***	0.256		0.293	
	Constant	− 3.190	***	− 1.439	***	− 1.756	***

Note:
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.10$.

The absorptive capacity of new knowledge (H3) was found to influence the use of industrial design, particularly ED. The demand for university graduates was positively related to the use of ED (compared to non-use of design and SD). Greater professionalization was linked to the use of ED. In contrast, lower professionalization was linked to the use of SD and the non-use of design. No significant differences between SD users and non-users of design were detected in terms of hiring university graduates.

Firms' knowledge of new technologies was significantly linked to the use of design (H4). Whereas the use of internal networks was linked only to ED (compared to SD and to the non-use of design), the use of mobile data was linked to both ED and SD (compared to the non-use of design). Mobile data is a more recent innovation, so the use of mobile data implies up-to-date technological systems and a greater knowledge of new technologies on the part of the firm, thereby differentiating the firm from firms that do not use design.

Firms' exposure to international competition (H5)—imports or exports— was significant in explaining the use of design. Firms that faced competition from foreign companies in the domestic market were more likely to use ED or SD than they were not to use design. This variable captures the situation whereby firms have already lost market share in the domestic market because of imports.

The technological intensity within the sector (H6) was found to influence the use of ED services. A firm with low technological intensity was more likely to use ED than it was not to use design, compared to a firm situated in a sector with medium or high technological intensity. The low technological intensity sector has a clear strategic need for the use of professional design. In terms of the technological intensity of the sector, we did not detect differences between SD users and ED users, nor between SD users and non-users of design.

5. Discussion

Certain factors that explain the use of design services relate to the firm, whereas others relate to the sector. By studying these factors, we identified several results that enhance our understanding of the differences between SD and ED. The findings support the assertions that ED differs from SD and that these differences have important implications for public policies to promote competitiveness as well as for managers seeking to define business strategies.

Although we did not observe differences in the use of ED or SD depending on the size of the firm, smaller firms were linked to a greater use of SD (compared to non-users) (H1). According to the literature, this finding may relate, in SMEs, to weaker capabilities (Walsh & Roy, 1985) and less formal design (Silva-Failde et al., 2008). These findings are reasonable, particularly when studying the relationship between design and innovation, because the findings of studies that have linked size and innovation are ambiguous (Becheikh, Landry, & Amara, 2006).

Regarding availability of financial resources, we did not observe differences between users of SD and users of ED (H2). Encounteringcertain financing problems (rejection of bank loan applications) among firms that use SD implies that SD is related not only to smaller firms, but also to firms with greater financial restrictions than firms that do not use design. At least in the case of SD, this finding supports the thesis of Verganti (2008), who argued that the availability of resources is not a significant restriction for the use of design because the proportion of SD users is higher among firms with certain restrictions than among firms that do not have this restriction. In contrast, our findings support neither Walsh and Roy (1985), who cite financing as a restriction for the use of design, nor Viljamaa (2011), who found that resource limitations may lead firms to defer the use of design. Both of the aforementioned studies indicate that firms in better financial positions have access to ED.

Knowledge absorptive capacity (H3) aids the knowledge transfer and co-production process, which leads to the hiring of professionals among whom there is strong interaction and collaboration (Den Hertog, 2000; Ravasi et al., 2008). This process of knowledge transfer and coproduction is driven by the designers in their dual role as translators (Vanchan, 2007; Verganti, 2008; Walsh & Roy, 1985) and agents of knowledge dissemination (Bertola & Teixeira, 2003; Verganti, 2008).

The link between SD use and a lower degree of professionalization in relation to ED clearly shows restrictions in the use of profesional design that derive not only from financial issues, but also from problems in accessing knowledge. These problems include SMEs' poor experience in using design and not knowing where to look for design professionals (European Commission, 2009; von Stamm, 1998). Thus, as well as being smaller and having greater financial problems than non-users of SD, firms that use SD are less professionalized than firms that use ED.

A greater knowledge of new technologies (access to ICTs) is linked to a greater use of design (H4). For at least one of the proxy variables (i.e., use of internal networks), users of ED tended to use technology more than users of SD did. Similarly, mobile data (i.e., the technology that is most modern and has the weakest requirements in terms of the scale of the firm) was significantly linked to both forms of design. This link provides evidence that technological knowledge is lower in firms that do not use industry design services and that greater use of design services is associated with introducing ICT (Gotsch et al., 2011).

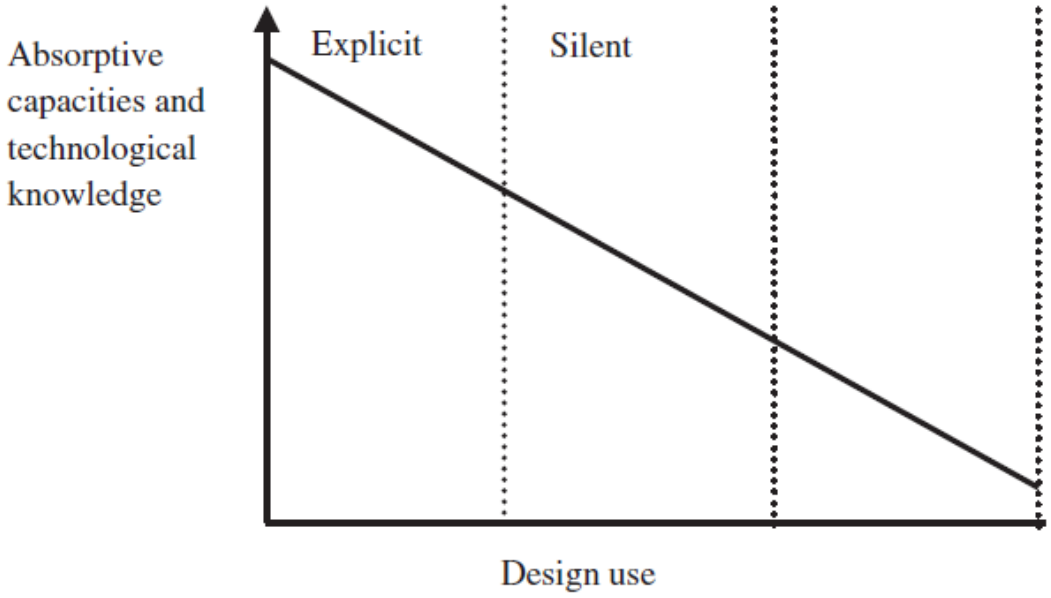

Fig. 1. Absorptive capacity and technological knowledge by design use.

Accordingly, there seem to be indications that knowledge varies as a function of absorptive capacity and technological knowledge: absorptive capacity and technological knowledge are high in firms that use ED, low in firms that do not use design services, and intermediate in firms that use SD. The level of knowledge is clearly lower in firms that use SD than in firms that use ED. Fig. 1 illustrates a possible form for this relationship, which could also have other representations such as a line with sudden peaks or troughs.

Internationalized companies have a greater use of ED (H5), which supports Tether's (2009) and Verganti's (2008) affirmation that exporting firms use design more intensively. Based on our findings, we can extend this affirmation by adding that, in internationalized firms, the intensity of use of design is linked to ED, which is more professionalized and more advanced than SD.

In terms of the technological intensity of the sector (H6), sectors with greater use of design, particularly ED, have low technological intensity. Design is therefore important for firms in traditional, nontechnological sectors, which base their competitive strategies on design rather than R&D (Tether, 2005a; Walsh, 1996). Accordingly, while these sectors are denoted “low technological intensity,” they could equally be denoted “high design intensity.”

Firms belonging to sectors with low technological intensity are intensive users of new technologies. Although this study refers in particular to ICT use, Tunzelman and Acha (2005) reported that non-technology- based sectors are also key users of new technologies. According to Von Tunzelman and Acha (2005), these new technologies are, broadly speaking, biotechnology and intelligent materials as well as ICTs. For example, in the textile sector, these new technologies might be linked to the development of synthetic fibers. Thus, innovation in sectors with low technological intensity derive largely from transforming and rearranging knowledge that is widely known, together with components and technologies that are developed by others (Tunzelmann & Acha, 2005).

New technologies offer massive opportunities for companies to innovate (Verganti, 2008) and undertake actions that aid their development. ED allows firms to benefit from and enhance the effects of new technological innovations, particularly if these firms are focused on design-driven innovation (Verganti, 2008). Accordingly, Verganti (2008) and Walsh (1996) also mention non-technological innovations derived from design.

6. Conclusions

This study contributes to the literature by identifying three groups of dimensions related to firms' use of design: structural dimensions refer to size (H1) and barriers, particularly financial barriers, to design use (H2); dynamic dimensions refer to knowledge (H3), the use of new technologies (H4), and the relationship between the firm and foreign markets (H5); and sector technology intensity dimensions refer to the intensity of technology within the sector (H6).

The variables in the group of structural dimensions generally do not emerge as relevant variables for explaining the use of design or the differences between SD and ED. Nevertheless, these variables provide some clues as to the characteristics of SD users.

The variables in the dynamic group make the largest contribution. Absorptive capacity, proxied as the use of design professionals, highlights the differences in capabilities between SD users and ED users, with higher professionalization among ED users. Similarly, ED users tend to use technology more than SD users do, at least in the case of one proxy variable (use of internal networks). Users of both SD and ED use new technologies (use of mobile data) more than non-users of design do. This finding implies greater knowledge of new technologies among users of design than among non-users of design. There seems to be a clear relationship between design use (ED and SD) and the loss of market share to imports. It would therefore seem that the use of design in these firms could be partly explained as a reaction to competition from imported products. Nevertheless, the use of ED, unlike the use of SD, is linked to access to foreign markets, which generally requires greater capabilities. Therefore, ED is not only linked to greater professionalization and greater technological knowledge, but also to developments and knowledge that helps design users exports their products. This finding implies that, in terms of firms' competitiveness, ED could be more useful than SD.

Finally, regarding the technological intensity within the sector, sectors with low technological intensity also have high design intensity. Users of design are also linked to the use of new technologies. According to the literature, using design to incorporate new technologies (nano, bio, ICTs, etc.) into products gives firms the best chance to innovate and encourage actions to enhance their competitive position.

6.1. Practical implications

The findings of this study lend support to several actions at the firm and institutional levels for competitive improvements at the firm or sector level. The proposals for improvement are expected to have a considerable impact on firms' competitiveness. Given the current context of globalization and the importance of knowledge in production, these design-related factors help us rethink the role not

only of the state, but also of companies and institutions in defining policies to improve competitiveness in Argentina.

At the company level, firms should:
• Take actions that encourage greater design content in their products, seeking ways for this greater design content to aid the development and inclusion of innovations.
• Encourage the training of employees who participate in the design of products within the firm, seeking to attain greater design professionalization, especially among firms with SD.
• Continue to search for state-of-the-art technology in design, process, and materials, and include these elements in design.

At the institutional level, public and private institutions should:
• Take actions that allow SMEs to capitalize on relevant know-how and incorporate new routines that enable access to know-how that leads to best practice in industrial design.
• Help firms to access design services and encourage training of people with design knowledge in areas where no such knowledge previously existed.
• Help firms identify and incorporate new technological developments both within the sector and from other sectors that directly influence the likelihood of adding value by designing or redesigning products.

6.2. Limitations and future lines of research

One of this study's limitations is that the model represents a structure of causal relationships among variables and conceptual dimensions under the assumption that the variables observed are indicators of these characteristics. The survey and the quantitative method restricted insight in some areas. Likewise, when analyzing differences across sectors, the openness in these dimensions led to a small number of questionnaire responses for each characteristic. The limitations and findings highlight two suggestions for future research:

• Conduct a study at the sector level employing a larger sample, a regional focus, and a qualitative method.
• Extend research into the potential existence of a knowledge gradient as a function of the use of different types of design.

References

Balogun, J., & Jenkins, M. (2003). Re-conceiving Change Management: A Knowledgebased Perspective. European Management Journal, 21(2), 247–257.

Becheikh, N., Landry, R., & Amara, N. (2006). Lessons from innovation empirical studies in the manufacturing sector: A systematic review of the literature from 1993–2003. Technovation, 26(5–6), 644–664.

Bertola, P., & Teixeira, J. C. (2003). Design as a knowledge agent: How design as a knowledge process is embedded into organizations to foster innovation. Design Studies, 24(2), 181–194.

Bianchi, P., & Labory, S. (2011). Industrial policy after the crisis: The case of the Emilia-Romagna region in Italy. Policy Studies, 32(4), 429–445.
Candi, M., & Gemser, G. (2010). An Agenda for Research on the Relationships between Industrial Design and Performance. International Journal of Design, 4(3), 67–77.
Chiva, R., & Alegre, J. (2007). Linking design management skills and design function organization: An empirical study of Spanish and Italian ceramic tile producers. Technovation, 27(10), 616–627.
Czarnitzki, D., & Thorwarth, S. (2012). The contribution of in-house and external design ctivities to product market performance. Journal of Product Innovation Management, 29(5), 878–895.
Dell'Era, C., Marchesi, A., & Verganti, R. (2010). Mastering technologies in design-driven innovation. Research-Technology Management, 53(2), 12–23.
Den Hertog, P. (2000). Knowledge Intensive Business Services as Co-Producers of Innovation. International Journal of Innovation Management, 4(4), 491–528.
Denford, J. (2013). Building knowledge: Developing a knowledge-based dynamic capabilities typology. Journal of Knowledge Management, 17(2), 175–194.
European Commission (2009). Design as a driver of user-centred innovation. (Commission Staff Working Document).
Francis, A., & Winstanley, D. (1988). Managing new product development: Some alternative ways to organise the work of technical specialists. Journal of Marketing Management, 4(3), 249–260.
Freeman, C. (1982). The economics of industrial innovation. London: Francis Pinter.
Fritsch, M., & Falck, O. (2010). New business formation by industry over space and time: A multidimensional analysis. Regional Studies, 41(2), 157–172.
Gemser, G., & Leenders, M. A. A. M. (2001). How integrating industrial design in the product development process impacts on company performance. Journal of Product Innovation Management, 18(1), 28–38.
Gorb, P., & Dumas, A. (1987). Silent design. Design Studies, 8(3), 150–156.
Gotsch, M., Hipp, C., Gallego, J., & Rubalcaba, L. (2011). Knowledge intensive services sector: final sector report (Europe INNOVA sectoral innovation watch). EU: European Commission.
Grant, R. (1996). Toward a knowledge-based theory of the firm. Strategic Management Journal, 17, 109–122.
Haskel, J., Cereda, M., Crespi, G., & Criscuolo, C. (2005). Design and Company Performance: Evidence from the Community Innovation Survey. DTI Report London.
Hertenstein, J., Platt, M. B., & Veryzer, R. W. (2005). The impact of industrial design effectiveness on corporate financial performance. Journal of Product Innovation Management, 22(1), 3–21.
Hu, B., Shao, B., & Palta, M. (2006a). Pseudo-R2 in logistic regression model. Statistica Sinica, 16(3), 847–860.
Hu, B., Shao, J., & Palta, M. (2006b). Pseudo-R 2 in logistic regression model. Statistica Sinica, 847–860.
Huber, P. (1967). The behavior of maximum likelihood estimates under non-standard conditions. Proceedings of the Fifth Berkeley Symposium on Mathematica Statistics and Probability, 1(1), 221–233.

ICSID (2013). Definition of design. http://www.icsid.org/about/about/articles31.htm.
INDEC (2005). National Economic Census 2004/2005: Methodological Synthesis. Argentina. Recovered from https://www.indec.gov.ar/economico2005/CNE04_metodologia_ 040810.pdf.
Kleinknecht, A. (1989). Firm size and innovation. Small Business Economics, 1(3), 215–222.
Kumar, M., & Noble, C. H. (2016). Beyond form and function: Why do consumers value product design? Journal of Business Research, 69(2), 613–620.
Marsili, O., & Salter, A. (2006). The dark matter of innovation: Design and innovative performance in Dutch manufacturing. Technology Analysis & Strategic Management, 18(5), 515–534.
Mate-Sanchez-Val, M., & Harris, R. (2014). Differential empirical innovation factors for Spain and the UK. Research Policy, 43(2), 451–463.
McRobbie, A. (1998). British fashion design: Rag trade or image industry? Routledge.
Muller, E., & Zenker, A. (2001). Business services as actors of knowledge transformation: The role of KIBS in regional and national innovation systems. Codification of Knowledge, 30(9), 1501–1516.
Nickerson, J., & Zenger, T. (2004). A knowledge-based theory of the firm—The problemsolving perspective. Organization Science, 15(6), 617–632.
OECD (2000). Encourage SMEs to innovate in a global economy. Conférence des ministres responsables des PME et ministres de l'industrie. (Bologna. Retrieved from) http://www. oecd.org/cfe/smes/.
OECD (2011). ISIC REV. 3 technology intensity definition: Classification of manufacturing industries into categories based on R&D intensities. Recovered from http://www.oecd. org/sti/ind/48350231.pdf.
Piccoli, G., & Ives, B. (2005). Review: IT-dependent strategic initiatives and sustained competitive advantage: A review and synthesis of the literature. MIS Quarterly, 29(4), 747–776.
Polanyi, M. (1966). The tacit dimension. London: Routledge & Kegan Paul.
Potter, S., Roy, R., Capon, C. H., Bruce, M., Walsh, V., & Lewis, J. (1991). The benefits and costs of investment in design: Using professional design expertise in product, engineering and graphics projects. Milton Keynes: Open University Press.
Ravasi, D., & Lojacono, G. (2005). Managing design and designers for strategic renewal. Long Range Planning, 38(1), 51–77.
Ravasi, D., Marcotti, A., & Stigliani, I. (2008). Conditions of success and failure in collaborations between business firms and design consultancies: The designers' perspective. The creative industries and intellectual property. London: DIME.
Rusten, G. (1997). The role of geographic concentration in promoting competitive advantage. The Norwegian furniture industry. Norwegian Journal of Geography, 51(4), 173–185.
Silva-Failde, D., Becerra, P., Yoguel, G., & Milesi, D. (2008). Opening the black box of design: The importance of innovation processes in the clothing sector. XII Reunión Anual de la Red PYMES Mercosur- Universidad Nacional de General San Martín Argentina.

Talke, K., Salomo, S., Wieringa, J., & Lutz, A. (2009). What about design newness? Investigating the relevance of a neglected dimension of product innovativeness. Journal of Product Innovation Management, 26(6), 601–615.
Tether, B. (2005a). Evaluating the impacts of design and design support. SEE design bulletin, 10–11 (EU).
Tether, B. (2005b). The role of design in business performance. ESRC Centre for Research on Innovation and CompetitionUniversity of Manchester Report.
Tether, B. S. (2009). Design in innovation: Coming out from the shadow of R&D, an analysis of the UK innovation surveys of 2005. London: Department for Innovation, Universities and Skills, HM Government.
Tunzelmann, N., & Acha, V. (2005). Innovation in 'low-tech' industries. In J. Fagerberg, D. Mowery, & R. Nelson (Eds.). The Oxford handbook of innovation (pp. 407–432). Oxford: Oxford University Press.
Vanchan, V. (2007). Communication and relationships between industrial design firms and their customers. The Industrial Geographer, 4(2), 28–46.
Verganti, R. (2008). Design, meanings, and radical innovation: A metamodel and a research agenda. Journal of Product Innovation Management, 25(5), 436–456.
Viljamaa, A. (2011). Exploring small manufacturing firms' process of accessing external expertise. International Small Business Journal, 29(5), 472–488.
von Stamm, B. (1998). Whose design is it? The use of external designers. The Design Journal, 1(1), 41–53.
Walsh, V. (1996). Design, innovation and the boundaries of the firm. Research Policy, 25(4), 509–529.
Walsh, V., & Roy, R. (1985). The designer as 'gatekeeper' in manufacturing industry. Design Studies, 6(3), 127–133.
White, H. (1980). A heteroscedasticity-consistent covariance matrix estimator and a direct test for heteroscedasticity. Econometrica, 48(4), 817–830.
Zollo, M., & Winter, S. (2002). Deliberate learning and the evolution of dynamic capabilities. Organization Science, 13(3), 339–351.