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Financing constraints and SME innovation during economic crises

Restricciones Financieras y la innovación en la PYME durante las crisis económicas

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Abstract

Purpose – The purpose of this paper is to provide a better understanding of the determinants of small and medium-sized enterprises (SME) financing constraints and their impacts on investments in innovation. To explicate these factors, the authors use a general definition of innovation, distinguishing between product and process innovations, and highlight the role played by banking relationships.

Design/methodology/approach – On the basis of a literature review covering works specializing in innovation, financing constraints, and SME characteristics, a quantitative study is carried out in Spain, using a sample composed by 267 Spanish SMEs. Information was gathered by applying surveys addressed to the firm managers.

Findings – The findings reveal that financing constraints hinder innovation among Spanish SMEs functioning in hostile environments, though long-term banking relationships can moderate these financing constraints. The longer the duration of a firm's banking relationship, the fewer financing constraints it faces, because the relationship significantly reduces information asymmetry.

Practical implications – To reduce financing constraints on their innovation, SMEs should establish long relationships and low debt concentration with their main bank. The more banks a firm works with, the greater its financing constraints. The findings have managerial implications, not just for firms but also for government policymakers and providers of consulting services.

Originality/value – This paper provides an in-depth analysis of the factors that affect innovation, along with insights into which financing constraints limit innovation during a severe recession.

Keywords Innovation, SMEs, Financial constraints, Manufacturing, Banking relationships

Paper type Research paper

Resumen

Propósito – Este trabajo profundiza en los determinantes de las restricciones financieras en las PYMEs y su impacto en la inversion en innovación durante una época de crisis económica. Para explicar estos factores, se ha utilizado una definición general de innovación distinguiendo las

JEL Classification — O32, G30, M10

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innovaciones en productos y procesos, y considerando el papel desempeñado por las relaciones bancarias.

Diseño/metodología/enfoque – Sobre la base de la revisión de la literature donde se encuentran trabajos centrados en innovación, restricciones financieras y características en la PYME, llevamos a cabo un análisis cuantitativo en España usando una muestra de 267 empresas españolas. La información se recopila a través de una encuesta al gerente de la empresa.

Resultados – Los resultados muestran que las restricciones financieras perjudican la innovación en las PYMEs que se encuentran en entornos hostiles, aunque es destacable que las relaciones bancarias de larga duración pueden atenuar estos efectos. Cuanto más sólida, en términos de tiempo, sea la relación con la entidad financiera principal, menores restricciones financieras tendrá la empresa puesto que esta relación disminuye significativamente los problemas de información asimétrica entre los agentes.

Implicaciones prácticas – Para reducir los efectos perversos de las restricciones financieras sobre la innovación en la PYME, la empresa debería construir relaciones bancarias de larga duración y mantener una baja concentración de las deudas con el banco principal. Por otra parte, cuanto mayor es el número de bancos con el que la empresa trabaja mayores son las restricciones financieras a las que se enfrenta cuando se plantea inversions en innovación. Estos resultados tienen importantes implicaciones tanto para los empresarios, como para los agentes políticos dinamizadores de la economía y los consultores de empresas.

Originalidad/valor – Este trabajo realiza un análisis en profundidad de los factores que afectan a la innovación en la PYME, junto con ideas sobre cómo las restricciones financieras están afectando a la innovación durante una crisis económica severa.

Palabras clave Innovación, PYME, Restricciones financieras, Industrial, Relaciones bancarias

Tipo de papel Trabajo de investigación

1. Introduction

A broad consensus highlights the benefits of firm investments in innovation as a means to remain competitive; Hurley and Hult (1998), for example, assert that innovation affects firm survival. However, uncertainty associated with the success achieved through investments in innovation can also create uncertainty regarding access to external financing. Investments in innovation, as opposed to other investments, tend to feature substantial asymmetric information, and the complexity of innovation projects compounds the challenges for outsiders seeking to assess their potential value. Such difficulties may lead to credit rationing, especially during economic recession periods. Asymmetric information, bankruptcy risks, and agency conflicts all increase external financing costs (Madrid-Guijarro *et al.*, 2009; Van Auken, 2001), which in turn might constrain a firm's investment behavior, due to the limited availability and cost of capital if its internal resources are insufficient to fund such investments (Bartolini, 2013). This limitation is likely, given that, as shown by Hall (1992), Himmelberg and Petersen (1994), and Czarnitzki and Hottenrott (2010), internal funding sources are more important for research and development (R&D) than for ordinary investments.

Previous literature notes some financing constraints associated with investing in innovation or R&D among large firms (Bond *et al.*, 2003; Mulkay *et al.*, 2001). Aghion *et al.* (2010) argue that financially constrained firms are less likely to invest in innovation because they are subject to long-run macro-economic shocks. However, previous research offers little evidence about the extent to which small and medium-sized enterprises (SMEs) commit to innovation, which is especially problematic when it comes to understanding their investments during economic recessions.

In response, this study analyzes the relationship between SME investment in innovation and the financing constraints these enterprises face, using a sample of 267 Spanish manufacturing firms during 2011-2012, a period of substantial economic

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distress in Spain. According to the European Central Bank (2013), Spain experienced unfavorable financing conditions, in terms of the costs of financing, banks' willingness to lend, financing obstacles, and collateral requirements. Access to finance also continues to be a dominant concern for Euro-area SMEs (European Central Bank, 2013). This study seeks to provide a better understanding of the determinants of SME financing constraints and their impacts on investments in innovation. To explicate these factors, we use a general definition of innovation but distinguish between product and process innovations. Accordingly, we provide an in-depth analysis of the factors that affect innovation, along with insights into the financing constraints that limit innovation during a severe recession. The findings reveal that financing constraints hinder innovation among Spanish SMEs functioning in hostile environments, though long-term banking relationships can moderate these financing constraints. The longer the duration of a firm's banking relationship, the fewer financing constraints it faces, because the relationship significantly reduces information asymmetry.

To derive these results, we began with a review of pertinent literature, outlined in the following section. We then present the sample and methodology used to analyze the data, followed by the results of the analysis. Finally, we conclude with some insights and limitations.

2. Innovation and financing constraints

Capital structure theory contends that firms choose financing that reduces their cost of capital, after identifying optimal levels of equity and debt. In perfect capital markets, external finance is a perfect substitute for internal finance (Modigliani and Miller, 1958), and financing decisions simply reflect the business owner's preferences (Hernández-Cánovas and Koëter-Kant, 2008; Jordan *et al.*, 1998). This assumption of perfect capital markets is inconsistent with the real-world conditions of information asymmetry, incomplete markets, and different investments (Hall, 2010; Myers and Majluf, 1984; Stiglitz and Weiss, 1981).

For example, investment in innovation differs from other investments; it may entail investments in R&D, training, capital equipment, or marketing expenses for new products and processes (Hall, 2010). Many expenditures are devoted to compensating highly educated employees, who possess valuable knowledge that firms need to retain. Innovation is also risky, because the returns are long term and uncertain (Carreira and Silva, 2010). Uncertainty is particularly high at the beginning of the project but declines over time as information about the likelihood of success becomes available. However, firms are reluctant to release information about the success of their projects for fear of losing their competitive advantage, meaning that asymmetric information is common (Carreira and Silva, 2010). Full disclosure increases the potential for competitor imitation and the unwanted spread of confidential information (Anton and Yao, 2002; Bhattacharya and Ritter, 1983).

In turn, banks are reluctant to finance innovation investments, because of their high risk and asymmetric information. In particular, asymmetric information reduces the potential accuracy of banks' credit risk assessments, resulting in adverse selection problems (e.g. the lemons market, Akerlof, 1970) and poor monitoring efficiency. The information opacity of a firm's projects is likely to affect lenders' financing decisions, especially if lenders cannot assess the quality of these innovative activities (Carpenter and Petersen, 2002; de Meza, 2002; Laursen and Salter, 2005). Stiglitz and Weiss (1981) also contend that information opacity cannot be overcome by increasing

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the cost of debt, because doing so would hinder bank performance. The best firms would not apply for loans (adverse selection effect), and other firms would choose riskier investments (moral hazard effect). These information transparency challenges are difficult to overcome, especially for early stage innovation, because innovation assets cannot be used as collateral, and immediate profits will not be sufficient to repay the debt.

Furthermore, the information problems are more severe for small, young companies (Becchetti and Trovato, 2002; Honjo and Harada, 2006). A number of studies reported that financing limitations constrained innovation and growth among SMEs (Czarnitzki, 2006; Hall, 1992; Hao and Jaffe, 1993; Hewitt-Dundas, 2006; Himmelberg and Petersen, 1994; Hyytinen and Toivanen, 2005; Mohnen, *et al.,* 2008; Savignac, 2008; Silva and Carreira, 2012). Hottenrott and Peters (2012) note that firms with high innovative capability are likely to have unexploited innovation projects; those with high innovative capability and low levels of internal funds are likely to experience funding constraints. However, financing constraints might also foster innovation success (Hewitt-Dundas, 2006). According to Bicen and Johnson (2014), intentions, inspiration, integration, and indefatigability moderate the effects of resource uses on innovation performance and act as catalysts for successful innovation when resources are limited. Still, persistent financial constraints are likely to be detrimental to the success of innovation, particularly for SMEs (Hewitt-Dundas, 2006), though Mina *et al.* (2013) find limited evidence of financing constraints among SMEs during favorable macro-economic periods. On the basis of this discussion, we predict:

H1. Financial constraints on innovation relate directly to lower levels of innovation by SMEs.

Several studies suggest that firms can overcome asymmetric information problems and obtain access to bank financing by establishing closer banking relationships (Angelini. *et al.*, 1998; Berger and Udell, 1995; Harhoff and Korting, 1998; Hernández-Cánovas and Martínez-Solano, 2007; Petersen and Rajan, 1994). Grünert *et al.* (2005) state that banks can deal with information asymmetry by monitoring, such that they obtain private information over time during multiple interactions or by providing multiple financial services. By assigning internal credit ratings to appraise the creditworthiness of borrowers, banks can use the information for loan approval, pricing, monitoring, and loan-loss provision decisions. The information a bank generates through its relationship with the firm is more valuable if it is not easily available to other financial institutions (Carletti, 2004). When a bank holds a larger share of a firm's debt, it acquires more precise information, relative to other lenders (Giannetti, 2012). In examining firms' credit availability during the 2007-2009 financial crisis, Cotugno *et al.* (2013) also find that relationship exclusivity can mitigate credit rationing.

However, a close lending relationship could also provoke negative consequences if the firm is "informationally captured," because the lending bank can extract additional rents or threaten to deny new funds (Rajan, 1992; Sharpe, 1990), especially to opaque, risky, innovative firms. Greater debt concentration might also increase the chances of the denial of new loans, if its capacity becomes exhausted. A firm that deals with more than one bank can introduce competitive forces into its credit acquisition process and avoid becoming locked into a relationship with a single bank. Negotiations with multiple banks should avoid information monopolies about the borrower's quality or rent extraction attempts (Baas and Schrooten, 2007; Steijvers *et al.*, 2010). Yet, because

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risky firms tend to work with many banks (Ongena *et al.*, 2012), the number of banks a firm works with offers a signal of poor firm quality and financing constraints (Giannetti, 2012). Therefore, we hypothesize:

H2. Financing constraints are directly associated with the characteristics of the firm-bank relationship.

3. Methodology

3.1 Sample

The sample consists of 267 manufacturing SMEs from the Murcia region in Spain, which provided data by responding to a questionnaire addressed to each firm's CEO. These respondents are appropriate, because SME managers are the most important decision makers (van Gils, 2005), and managerial perceptions have significant influences on firms' strategic behaviors (O'Regan and Sims, 2008). In fact, De Villa and Rajwani (2013) found that the response adopted by each organization was significantly influenced by their manager's perception of the political crisis and, consequently, was prone to producing a particular performance outcome. The fieldwork took place between June and November 2013. The questionnaire focussed on firm-specific characteristics, including innovation activities and financial constraints to innovation during the previous two years. In addition, we gathered financial information from the balance sheets and earning statements of the sample firms, using the SABI database by INFORMS[1].

The sample design followed stratified sampling in finite populations. The total population of 1,962 firms in the SABI database was segmented by activity, and we determined the number of companies in each strata using information provided by the INE Central Company Directory (DIRCE, 2015). The sample excluded companies with fewer than five employees. Sample size was determined so the maximum margin of error for estimating a proportion was less than 0.05 points with a 95 percent confidence index. The final sampling error was 0.056. Companies that refused to participate in the project were replaced by a similar company in the same industry and geographic area. We used these replacement respondents to test for non-response bias (Nwachukv *et al.*, 1997), such that the responses from firms that initially agreed to participate (80 percent of the sample) were contrasted with those that responded to the follow-up interviews (20 percent of the sample). According to both *t*-tests and χ^2-tests, none of the variables in the model differed significantly between these two groups.

Table I describes the sample by activity distribution. Most firms operated in the food, beverage, and tobacco (18.7 percent); basic and fabricated metals (15.0 percent); furniture (13.5 percent); or machinery/equipment (10.1 percent) industries. The remaining firms were distributed relatively evenly across other industries.

3.2 Main characteristics of Region of Murcia

Murcia is located in southeast Spain; it has a population of 1,466,812 inhabitants and its per capita GDP was €18,529 in 2014, reaching 81.3 percent of the average for Spain (CREM, 2015). The unemployment rate in 2014 was 27.3 percent, while in Spain it was 23.7 percent (INE, 2015). The total number of firms in the Region of Murcia is 86,782, of which 95.71 percent are micro-enterprises, 3.65 percent are small enterprises, 0.56 percent are medium-sized and 0.08 percent are larger ones (over 250 employees). Therefore, business in the region is made up mainly of SMEs (99.92 percent of the

Industry	Number of respondents	% of total
Machinery and equipment	27	10.1
Chemicals	13	4.9
Services	12	4.5
Recycle, energy and water	10	3.7
Other	9	1.9
Food, beverage, tobacco	50	18.7
Basic and fabricated metals	40	15.0
Furniture	36	13.5
Wood and cork	22	8.2
Textiles	20	7.4
Other non-metallic minerals	16	6.0
Paper, publishing, and printing	12	4.5

Table I.
Sample distribution

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companies, similar to the national average, 99.90 percent). The activity distribution according to gross added value is: services (71.2 percent); manufacturing (18.1 percent); construction (6.4 percent); and agriculture and fisheries (4.4 percent) (CREM, 2015).

The global economic crisis has also affected Murcia. During the 2008-2013 period, the economy of Murcia experienced a period of recession, involving a considerable drop in employment and competitiveness (CROEM, 2015). However, by 2014, the region had recovered, with an increase in its GDP of 0.7 percent (compared with 1.3 percent in Spain) and with favorable expectations for 2015, with an expected increase in GDP of 2.5 percent (compared to 2.3 percent in Spain) (CREM, 2015). This change in the economic situation was mainly due to a higher consumption of domestic demand and the devaluation of the euro against the dollar, which has strengthened its external sector (CROEM, 2015). Currently, the Region of Murcia faces the following challenges: to reduce unemployment; to improve productivity of their companies; and diversify its exports (BBVA, 2015).

In relation to this paper, the case of the Murcia Region is especially interesting because the economic crisis has seriously damaged the innovative capacity of its companies (Madrid Guijarro *et al.*, 2013). Spain is among the group of countries categorized as "moderate innovators" and is positioned below the EU average. Companies from Murcia are less innovative than national ones. The average R&D spending in the Region of Murcia was only 0.83 percent of the GDP – well below the national average, which stood at 1.30 percent (COTEC, 2014) – while R&D expenditure in companies in Murcia was 0.32 percent (0.69 percent in Spain). The number of employees in the high and medium high technology sector is represented by 3.2 percent of the working inhabitants; this percentage is clearly lower than the one for Spain (6.8 percent) (INE, 2014). This means that companies in the Region of Murcia are positioned at the bottom in terms of innovation intensity (percentage of expenditure on innovation) and profit for the innovative effort (measured by the percentage representing new or improved products on the turnover) (COTEC, 2014).

3.3 Models

Model 1: innovation. To evaluate the relationship between financial constraints and SME innovation, we used Equation (1) and conducted two regression analyses, in which we used product innovation as the first dependent variable, and process innovation as the second dependent variable. Both analyses relied on the same

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independent variables. Thus the model is:

$$Innovation_i = \beta_0 + \beta_1 Age_i + \beta_2 Size_i + \beta_3 Network_i + \beta_4 InnCapacity_i + \beta_5 Environment_i + \beta_6 FinancingConstraints_i + \varepsilon_i \quad (1)$$

To measure product innovation, we asked respondents to indicate whether their firm's competitive position was favorable or unfavorable in relation to its competitors (five-point Likert scale, 1 = "unfavorable" and 5 = "favorable"), on four items: number of new products or services launched over the past two years (2011-2012); first to market with new products/services; capacity to respond to innovative actions by competitors; and R&D investments in new products or services. Similar items measured process innovation.

With factor analysis, we compiled the information about both the product and process innovation variables (Table II). After confirming the reliability with Cronbach's α, our factor analysis verified that the indicators of product and process innovations could each be summarized by a single factor. The regression analysis therefore included product and process innovation as separate dependent variables. We considered these subjective measures, based on self-reports and reflecting the value judgments of the managers, appropriate for SMEs, because objective measures tend to underestimate the degree of innovation, whereas self-reporting can indicate managers' monitoring of innovation and identify obstacles that might inhibit innovation (Hughes, 2001; Kalantaridis and Pheby, 1999). In addition, perceptual measures correlate highly with objective measures of innovation and facilitate comparisons across firms in different industries (Frishammar and Hörte, 2005; Zahra *et al.*, 2000).

Age refers to the number of years since the establishment of the firm, and Size to the logarithm of number of employees in 2012. In addition, a positive effect of networking on SME innovation is well documented (Ahuja, 2000; Gronum *et al.*, 2012; Lee *et al.*, 2010; Rogers, 2004; Zeng *et al.*, 2010), such that through their network relationships, SMEs can obtain advantages associated with large firms (Nooteboom, 1994; Rothwell and Dodgson, 1994). Therefore, to measure networking, we asked respondents how

Type of innovation	Variables	Scale validation
Product innovation	Number of new or modified products introduced per year Entrepreneurial character of the company when introducing new products Speed of new products introduced by competitors R&D investment in new products	Cronbach's $\alpha = 0.816$ Factorial: 1 factor Explained variance: 65% Sig. Bartlett: 0.000 KMO: 0.773
Process innovation	Number of modifications in processes introduced per year Entrepreneurial character of the company when introducing new processes Speed of new processes introduced by competitors R&D investment in new products	Cronbach's $\alpha = 0.868$ Factorial: 1 factor Explained variance: 71.87% Sig. Bartlett: 0.000 KMO: 0.816

Table II.
Variables of innovation

Notes: Survey question: how has the position of your company evolved in relation to the competitors? 1 = very unfavorable and 5 = very favorable. Dependent variable: model innovation

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often their firm cooperates or collaborates with customers, suppliers, competitors, development agencies, technological center, technological providers, and universities (five- point Likert scale: 1 = "never" and 5 = "often"). In the factorial analysis, we identified two factors, one that features relations between the firm and its customers, competitors, and suppliers and a second factor that includes its relationships with institutional entities. Accordingly, we label Factor 1 NetworkMarket and Factor 2 NetworkInstitutions (Table III).

Variable	Items	Scale validation
Networking (Frequency of collaboration or cooperation)	*Factor 1: NetworkMarket* Customer Competitors Suppliers	Cronbach's $\alpha = 0.792$
	Factor 2: NetworkInstitutions Development agencies Technological parks Business associations Universities etc.	Cronbach's $\alpha = 0.868$ Explained variance = 61.54% Sig. Bartlett: 0.000 KMO: 0.855
Innovation capacity	*Factor 1: InnCapaRisk* In general, the top managers of my firm have a strong proclivity for high-risk projects In general, the top managers of my firm believe that owing to the nature of the environment, bold, wide-ranging acts are necessary to achieve the firm's objectives When confronted with decision-making situations involving uncertainty, my firm typically adopts a bold, aggressive posture in order to maximize the probability of exploiting potential opportunities	Cronbach's $\alpha = 0.859$
	Factor 2: InnCapaLearning Managers basically agree that our organization's ability to learn is the key to our competitive advantage The basic values of this organization include learning as key to improvement The sense around here is that employee learning is an investment, not an expense Learning in our organization is seen as a key commodity necessary to guarantee organizational survival	Cronbach's $\alpha = 0.920$ Explained variance = 77.4% Sig. Bartlett: 0.000 KMO: 0.853
Environment	Declining markets for products are a major challenge in our industry In our industry, actions of competitors are unpredictable Tough price competition is major challenge in our industry Market dynamism and uncertainty vary a great deal from one line our business to another	Cronbach's $\alpha = 0.734$ Factorial: 1 factor Explained variance = 73% Sig. Bartlett: 0.000 KMO: 0.756

Table III. Variables of networking, innovation capability, and environment

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Hottenrott and Peters (2012) note that firms with greater innovative capabilities (personnel qualification and training investment) were more likely to have unexploited innovation projects, and low levels of internal funds also left them more likely to be constrained. Thus, we use InnCapacity to represent the firm's innovation capacity (Yang, 2012). New knowledge developed through organizational learning (Hurley and Hult, 1998) and commitment to learning orientation (Verona, 1999; Yang, 2012) increase innovation capability. To measure commitment to learning, we asked respondents to rank the following statements on a five-point Likert scale (1 = "strongly disagree" and 5 = "strongly agree"): first, "Managers agree that our organization's ability to learn is key to our firm's competitive advantage;" second, "The values of this organization include learning as key to improvement;" third, "The sense around here is that employee learning is an investment, not an expense;" and fourth, "Learning in our organization is seen as a key commodity necessary to guarantee organizational survival" (Baker and Sinkula, 1999; Yang, 2012). To measure risk-taking propensity (Covin and Slevin, 1989; Yang, 2012), we instead asked respondents to rank their degree of agreement with three statements (five-point Likert scale, 1 = "strongly disagree and 5 = "strongly agree"): first, "In general, the top managers of my firm have a strong proclivity for high-risk projects;" second, "In general, the top managers of my firm believe that owing to the nature of the environment, bold, wide-ranging acts are necessary to achieve the firm's objectives;" and third, "When faced with decision-making situations involving uncertainty, my firm typically adopts a bold, aggressive posture in order to maximize the probability of exploiting potential opportunities." A factorial analysis identifies two factors: items linked to the risk-taking concept loaded on Factor 1, and those related to commitment to learning loaded on Factor 2. Both factors have Cronbach's α values greater than 8 (Table III).

Environment refers to the hostility and heterogeneity of the firm's environment, which we measured using a scale provided by Bojica and Fuentes (2012). Respondents indicated their agreement with five statements on five-point Likert scales (1 = "strongly disagree" and 5 = "strongly agree"): first, "In our industry, demand and customer preferences are unpredictable;" second, "Declining markets for products are a major challenge in our industry;" third, "In our industry, actions of the competitors are unpredictable;" fourth, "Tough price competition is a major challenge in our industry;" and fifth, "Market dynamism and uncertainty vary a great deal from one line of our business to another" (Table III).

To measure FinancingConstraints, we used the mean value respondents assigned to two statements on a five-point Likert scale (1 = "totally disagree" and 5 = "totally agree"): first, "During the last two years, profitable innovation projects have been abandoned because of lack of financing resources"; and second, "During the last two years, profitable innovation projects have been delayed due to lack of financing resources." Firms have the best information about the quality of their investment projects, so their responses to these items should reflect their investment opportunities (Silva and Carreira, 2012).

In turn, we predict that financial constraints affect firm innovation, associated with the asymmetric information and resulting complexity and risk (Hottenrott and Peters, 2012). Firms and investors may be reluctant to invest in innovation, especially during periods of heightened risk due to economic turmoil. Mohnen *et al.* (2008) and Savignac (2008) report that financial constraints have significant negative effects on innovation; such constraints are particularly important in Spain, because of the predominance of

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SMEs in this economy and the limited access to financing alternatives in Spanish capital markets (Mancusi and Vezzulli, 2010).

Model 2: financing constraints. The sensitivity of cash flows to investments has served as a traditional measure of financial constraints but may be problematic for several reasons (Kaplan and Zingales, 1997, 2000). The relationship between cash flows and investment might not indicate financial constraints effectively, because the level of free cash flows may depend on accounting methods and dividend policies that are designed to mitigate moral hazard problems (Dhanani, 2005). Cash flows and investments may be highly correlated during periods of high market demand, and measuring the impact of changes in cash flow in one period can be difficult, due to the nature of innovation investments (Hall, 2010; Lach and Schankerman, 1988). These arguments justify the use of a more direct measure of financial constraints (Hottenrott and Peters, 2012).

Accordingly, in our model to evaluate the factors that affect financing constraints on innovation, the dependent variable is our previously defined measure of financing constraints, namely, the mean value that respondents assigned to statements about delaying or abandoning profitable innovation projects due to a lack of financing resources (Silva and Carreira, 2012). The independent variables were similar to those in Equation (1). Thus:

$$\begin{aligned} FinancingConstraints_i = {} & \alpha_0 + \alpha_1 Age_i + \alpha_2 Size_i + \alpha_3 InnCapacity_i \\ & + \alpha_4 Environment_i + \alpha_5 FinancialHealth_i + \alpha_6 NBanks_i \\ & + \alpha_7 Debtconcentration_i + \alpha_8 Length_i + \delta_i \end{aligned} \quad (2)$$

Age and Size were measured as in Model 1. We also included our previous measure of InnCapacity (Yang, 2012), because finance theory includes the effect of risk on capital availability. Greater risk makes capital more expensive and enhances its constraints (Berger and Udell, 2006; Modigliani and Miller, 1958). Thus an innovative culture could constrain a firm's ability to acquire capital, especially if cultural differences significantly affect financing availability (Stulz and Williamson, 2003). Our Environment measure is the same as in Model 1 (Bojica and Fuentes, 2012). Ayyagari *et al.* (2008) note that the operating environment is among the most important constraints affecting the acquisition of capital and growth opportunities. Credit appears to be directly affected by the economic environment in which the firm operates (Berger and Udell, 2006), and a strong internal culture can enable firms to adapt to changing environments and improve their financial performance (Sørensen (2002) – a relationship predicated on reliable capital access).

For FinancialHealth, we used a scorecard measure (Garcia-Perez de Lema *et al.*, 1995) composed of several ratios: quick assets over current liabilities; total assets to total debt; total interest payments to sales; annual amortization to amortizable assets; and earnings before taxes over total debt. This indicator thus assesses a firm's bankruptcy probability, based on traditional bankruptcy models (Altman, 1968). It has also been used as a risk indicator in prior research (Baixauli and Módica, 2010).

We used NBanks to indicate the number of banks with which each firm works. Higher numbers might be detrimental, because of the greater risk of information spillovers if banks disclose information to rivals. Information disclosed to multiple

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banks often becomes available to rivals (Yosha, 1995), so Giannetti (2012) argues that the number of banks with which a firm works affects the availability of capital that can fund innovation. In contrast, Debtconcentration is the percentage of debt held by the main bank, because the bank concentration of debt affects access to information and to capital (Giannetti, 2012). Debt concentration is likely when the risk of lending declines (Ongena *et al.*, 2012), though banks may be reluctant to concentrate debt with a firm that is engaging in risky initiatives. Finally, Length is the logarithm of the number of years the firm has been working with its main bank. Benfratelio *et al.* (2008) report a significant, positive relationship between SME innovation and banking relationships, due to reduced financing constraints. Strong banking relationships should also reduce information asymmetry and increase access to funding for innovation (Herrera and Minetti, 2007).

4. Results

Table IV contains the descriptive information for the respondents and variables. The average age of the responding firms was 27 years, and they employed an average of 26 people in 2012. Approximately 36 percent of their debt was held by their main bank, though 24 percent of the firms had no debt. The correlations among the variables are shown in Table V.

We used ordinary least squares regression to clarify the relationship between financing constraints and innovation; in Table VI we provide the results of two separate regressions, with product innovation or process innovation as the dependent variable and the financing constraint variable as the independent variable in both cases. The control variables were age, size, environment, innovation capacity (InnoCapaLearning and InnoCapaRisk), and network (Networkmarket and Networkinstitutions). All regressions revealed variance inflation factors below 1.3, so multicollinearity was not a concern (Tabachnick and Fidell, 2001).

We found a negative, statistically significant coefficient for financing constraints in both regressions (product innovation coefficient = −0.081, *t*-value = −2.028; process innovation coefficient = −0.110, *t*-value = −2.762). That is, both product and process innovation were negatively affected by financing constraints, in support of *H1*. To the

Variables	Mean	Median	SD	Min.	Max.
Product innovation	−0.027	−0.022	1.00	−2.41	2.06
Process innovation	−0.016	0.120	1.00	−2.19	2.43
NetworkMarket	−0.002	0.063	1.00	−2.54	2.160
NetworkInst	0.009	−0.180	1.00	−1.60	3.30
InnCapaRisk	−0.002	−0.023	1.00	−1.89	2.90
InnCapaLearning	−0.001	0.084	1.00	−2.39	2.04
Environment	3.395	3.5	0.86	1	5
Financial health	59.32	44.9	31.2	0.21	99.88
Financing constraints	2.832	3	1.45	1	5
Number of employees (ln)	2.866	2.70	0.86	0.69	5.44
Age	27.01	24	15.6	2	95
NBanks	1.45	1.38	0.42	0.69	2.94
DebtConcentration	35.86	29.5	34.24	0	100
Length	2.76	2.83	0.62	0.69	4.23

Table IV.
Descriptive statistics

Note: $n = 267$

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Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Product innovation	1.00													
2. Process innovation	0.75**	1.00												
3. Age	−0.17**	−0.13*	1.00											
4. Number of employees	0.13*	0.17**	0.12	1.00										
5. Environment	0.20**	0.11	−0.06	−0.05	1.00									
6. InnCapaLearning	0.29**	0.27**	0.06	0.05	0.24**	1.00								
7. InnCapa risk	0.29**	0.29**	−0.12*	0.02	0.05	0.00	1.00							
8. NetworkInst	0.24**	0.29**	−0.04	0.24**	0.05	0.24**	0.24**	1.00						
9. NetworkMarket	0.14*	0.15*	−0.03	−0.11	0.08	0.17**	0.25**	0.00	1.00					
10. Financing constraints	−0.12*	−0.18**	0.01	−0.16**	0.24**	−0.01	−0.06	−0.03	−0.09	1.00				
11. FinancialHealth	0.16**	0.11	−0.10	0.15	0.04	0.06	−0.03	0.02	0.00	−0.20**	1.00			
12. NBanks	0.05	0.06	−0.01	0.41**	−0.02	0.00	−0.01	0.11	−0.07	0.04	0.00	1.00		
13. DebtConcentration	0.00	−0.01	−0.05	−0.16*	−0.03	0.05	0.05	0.02	0.03	0.18**	−0.06	−0.19**	1.00	
14. Length	−0.07	−0.06	0.42**	0.15*	0.03	−0.05	−0.18**	−0.05	−0.03	−0.11	0.15*	0.15*	−0.15*	1.00

Notes: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

Table V.
Correlations

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Variables	Product innovation Coefficients (*t*-student)	SE	Process innovation Coefficients	SE
Intercept	−0.493 (−1.498)	0.329	−0.197 (−0.601)	0.327
Age	−0.010 (−2.867)**	0.004	−0.007 (−2.096)**	0.004
Size	0.125 (1.856)*	0.067	0.134 (2.003)**	0.067
InnoCapaLearning	0.238 (3.984)***	0.060	0.211 (3.553)***	0.059
InnoCapaRisk	0.228 (3.847)***	0.059	0.215 (3.638)***	0.059
NetworkInst	0.083 (1.378)	0.060	0.146 (2.433)**	0.060
NetworkMarket	0.028 (0.487)	0.059	0.048 (0.819)	0.058
Environment	0.181 (2.647)**	0.068	0.091 (1.342)	0.068
FinancingConstraint	−0.081 (−2.028)**	0.040	−0.110 (−2.762)**	0.040
	$F = 10.392$ (0.000)		$F = 10.169$ (0.000)	
	Adjusted $R^2 = 22\%$		Adjusted $R^2 = 21.7\%$	
	Max. VIF = 1.2		Max. VIF = 1.2	

$$Innovation_i = \beta_0 + \beta_1 Age_i + \beta_2 Size_i + \beta_3 Network_i + \beta_4 InnCapacity_i + \beta_5 Environment_i + \beta_6 FinancingConstraints_i + \varepsilon_i$$

Table VI.
Determinants of innovation

Notes: SE, standard error; Max. VIF, maximum variance inflation factor. *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

extent that innovation affects a firm's ability to remain competitive in the market, financial constraints also hinder the firm's ability to achieve long-term viability. Because firms that do not innovate cannot compete or remain financially viable over time, a lack of investment in innovation during recessionary periods will create long-term viability issues.

The size variable is significantly and positively associated with both product (coefficient = −0.125, *t*-value = 1.856) and process (coefficient = 0.134, *t*-value = 2.003) innovation. Larger firms commit more to product and process innovation than smaller firms, perhaps because of their greater access to financial resources. Small firms likely experience greater financial difficulties than large firms during recessionary periods, because of their more limited access to financial resources. Their lack of investment in innovation may, in turn, expose them to a greater long-term risk of being uncompetitive.

Age was also significantly, negatively associated with innovation (product innovation coefficient = −0.010, *t*-value = −2.867; process innovation coefficient = −0.007, *t*-value = −2.096). Younger firms appear to engage in more innovation activities than older firms. Older firms tend to be more bureaucratic and slower to respond to market changes; younger firms may be more responsive and able to adapt through their innovations. The findings associated with innovation capacity also show that both product and process innovation activities are enhanced by commitment to learning and risk. Although networking is not associated with product innovation, it relates to process innovation. The hostility of the firm's environment encourages more product innovation but is not associated with process innovation.

In Table VII, we provide the results associated with the factors that affect financing constraints, including a significant, negative association between financing constraints and commitment to learning (coefficient = −0.182, *t*-value = −1.953). Firms' commitment to learning has a negative impact on financing constraints; it provides lenders with a signal that the firm is creating sufficient resources and capabilities to achieve high levels of innovation.

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Variables	Model 1 Coefficients (*t*-student)	SE	Model 2 Coefficients (*t*-student)	SE
Intercept	1.311 (1.670)*	0.785	2.2941 (3.014)**	0.760
LN(Age)	0.248 (1.413)	0.175	0.268 (1.539)	0.174
Size	−0.206 (−1.811)*	0.113	−0.216 (−1.974)**	0.109
InnCapacityRisk	−0.085 (−0.876)	0.096	−0.085 (−0.888)	0.096
InnCapaLearning	−0.182 (−1.953)*	0.093	−0.183 (−1.978)**	0.092
Environment	0.511 (4.402)***	0.116	0.508 (4.416)***	0.115
FinancialHealth	−0.157 (−2.399)**	0.065	−0.161 (−2.501)**	0.064
NBanks	0.454 (1.938)*	0.234		
Dummy 2 or 3 banks			−0.530 (−2.760)**	0.192
DebtConcentration	0.008 (2.998)**	0.003	0.008 (3.075)**	0.003
Length	−0.322 (−1.857)*	0.173	−0.335 (−1.950)*	0.172
	$F = 5.454$ (0.000)		$F = 5.970$ (0.000)	
	Adjusted $R^2 = 14.9\%$		Adjusted $R^2 = 16.3\%$	
	Max. VIF = 1.4		Max. VIF = 1.4	

$$FinancingConstraints_i = \alpha_0 + \alpha_1 Age_i + \alpha_2 Size_i + \alpha_3 InnCapacity_i + \alpha_4 Environment_i + \alpha_5 FinancialHealth_i + \alpha_6 NBanks_i + \alpha_7 Debtconcentration_i + \alpha_8 Lenght_i + \delta_i$$

Notes: Dummy 2 or 3 banks takes a value of 1 if the firm works with two or three banks, and 0 otherwise. SE, standard error; Max. VIF, maximum inflation factor. *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

Table VII.
Factors affecting financing constraints

The financial health variable is negative and significant (coefficient = −0.157, *t*-value = −2.399). That is, the firm's liquidity and profitability influence financing constraints. Innovation initiatives by firms in good financial health should not be constrained by financing. Furthermore, environmental hostility is directly, significantly associated with financing constraints (coefficient = 0.511, *t*-value = 4.402), such that more hostile environments invoke higher financing constraints. Finally, the results in Table VII indicate that banking relations are associated with financial constraints. These findings support *H2*.

The number of banks with which the firm works is positively associated with financing constraints (Model 1, coefficient = 0.454, *t*-value = 1.938). Firms that work with many banks experience more financing constraints than those that work with fewer banks (see also Ongena *et al.*, 2012). Recent research indicates that innovative firms are reluctant to sharing strategic information about their projects with many agents and prefer strong ties with just a few banks in order to avoid information leakage (Giannetti, 2012). To test this idea, in Model 2 (Table VII), we introduced a dummy variable, equal to 1 if the firm works with two or three banks, and 0 otherwise. Firms that work with two or three banks have lower financing constraints than others (Model 2, coefficient = −0.530, *t*-value = −2.760), suggesting that high quality, innovative firms prefer to work with a few banks, whereas lower quality firms must work with more banks.

A high debt concentration with the main bank also leads to higher financing constraints (coefficient = 0.008; *t*-value = 2.998). When companies exhaust their main bank credit, they incur more financing constraints, because a single financial institution bears the majority of the associated risk, and firms are also very dependent

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on this bank. Empirical studies confirm that the probability of collateral increases when a loan is granted by a main bank (Menkhoff *et al.*, 2006; Voordeckers and Steijvers, 2006). Because investments in innovation may be backed by intangible assets that cannot be used as collateral, innovative firms that maintain high debt concentrations with their main bank engage in greater pledging of collateral and more experience difficulty when acquiring financial resources. Finally, the number of years the firm has worked with its main bank lowers the financing constraints (coefficient = −0.322; *t*-value = −1.857), indicating that a long relationship enables a bank to obtain soft information about the firm, consistent with Herrera and Minetti's (2007) finding that banks' information fosters firm innovation. Consequently, longer relationships have a positive effect on small firms' capacity to innovate.

5. Discussion

Commitment to innovation is necessary for firms to remain competitive, especially in a global market where information is widely available and new products and services are continually being introduced (Cakar and Erturk, 2010; Madrid-Guijarro *et al.*, 2009). Firms with a limited innovation commitment likely lose customers and market share as their products and services become obsolete. Firms that are committed to innovation instead can expand their customer base and market share through market-based value creation. Innovation can thus improve financial performance and ultimately contribute to a country's economic growth (Hausman and Johnston, 2014).

The results of this study provide insights into the determinants of a firm's financial commitment to innovation during recessions. Committing financial resources to innovation initiatives in these difficult periods can be challenging, because firms often suffer from low revenue and growth. However, such investments may also offer significant opportunities to gain a competitive advantage in the market of other firms that must limit their financial investments in innovation (Hausman and Johnston, 2014).

This study focused on two innovation factors: first, those affecting product and process innovation; and second, those affecting a firm's financial constraints. The results are similar for both product and process innovations. Variables directly associated with product innovation include firm size, a firm's commitment to learning, risk acceptance, and the firm's operating environment. The age of the firm and financial constraints were inversely associated with product innovation. Thus, firms that are larger, are willing to accept more risk, are more committed to learning as a value, and operate in more hostile environments, engaging more in product innovation than firms that are smaller, less committed to innovation, unwilling to accept more risk, and that operate in a less hostile environment. Their greater resource bases grant larger firms more financial resources and enable them to commit to innovation more readily than smaller firms. Firms operating in a hostile environment must commit to innovation to remain competitive; this commitment is, in turn, associated with a willingness to take risks and expose themselves to greater risks. These findings are in line with previous findings (Madrid-Guijarro *et al.*, 2009).

Variables directly associated with process innovation included firm size, commitment to learning, risk acceptance, and network (institutional network). Age and financial constraints were inversely related to product innovation. That is, larger firms that commit more to process innovation, are willing to accept more risk, and have a better developed business network, engaged in process innovation more than smaller firms with lesser commitments to process innovation, that are not willing to accept more risk, and that have less developed business networks. These results are very

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similar to the findings for product innovation. Again, with their greater resource bases, larger firms can make stronger commitments to innovation than smaller firms (Herrera and Sánchez-González, 2013). In addition, firms with larger networks of business contacts can access pools of information and integrate them into their own innovation processes. More contacts are likely to provide more information about needs and opportunities in the market, helping these firms pursue more promising innovations and mitigate their risks of failure (Roxenhall, 2013).

We also evaluated factors that affected financial constraints on innovation and found that the environment, number of banks, and percent of debt held by a firm's main bank were directly associated with financial constraints. The size of the firm, organizational commitment to learning, financial health, and time the firm had worked with its primary bank were inversely associated with these financial constraints. Firms working in more hostile environments that deal with more banks and allow more of their debt to be held by their primary bank, tend to experience more financial constraints to innovation than firms operating in less hostile environments with a lower percentage of their debt held by a primary bank. Firms that were larger, exhibited a greater commitment to learning, were stronger financially, and had longer working relationships with their primary bank, experienced fewer financial constraints than their counterparts that showed less organizational commitment to learning, were financially weaker, and had shorter working relationships with their primary banks (Cornaggia *et al.*, 2015). Hostile operating environments and higher debt levels create more risk and impose greater demands on resources. These combined issues are likely to lead to situations in which firms limit their commitment to innovation and abandon projects sooner than firms that operate in less hostile environments and have less debt.

Commitment to innovation is difficult during recessionary periods, because of the greater resource restrictions that inherently arise. Firms with limited access to resources are most likely to exhibit a limited commitment to innovation; firms with greater access are better positioned to have and then maintain their commitment to innovation. Firms that are not committed to innovation risk losing their competitive advantage, because their offerings may rapidly become obsolete, especially if competitors are committed to innovation (Archibugi *et al.*, 2013).

The results are similar for both product and process innovation, suggesting that small firms operating in hostile environments and unwilling to assume risk, commit less to innovation and thus risk losing their competitive advantage in the market. Even when they face strong financial challenges, firms should attempt to maintain their commitment to innovation to ensure their long-term viability. Limited financial resources are among the most significant challenges to innovation during recessions, especially if revenues are also declining (Cornaggia *et al.*, 2015).

6. Conclusions

We have reported on the results of a study to examine factors associated with product and process innovation and the financial constraints to such innovation during a recent recessionary period, among a sample of 267 Spanish SME manufacturing firms. The data came from self-administered questionnaires, and the results indicated that firms with less access to resources and less commitment to learning, experienced lower innovation and more financial constraints than firms that had greater access to resources and more commitment to learning.

These findings have notable implications for firms, government policymakers, and consultants. Recessionary periods are among the most challenging when it comes to

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maintaining a commitment to innovation; they may also be the most important times to do so, if firms hope to maintain their competitive advantage. Firms that embrace innovation throughout the business cycle will be better positioned to remain competitive and achieve better financial performance than firms that reject innovation when times are tough. Ultimately, survival may depend on the degree to which firms embrace innovation as a core strategy during any phase of the business cycle.

Because commitment to innovation affects a firm's ability to remain competitive, it ultimately determines national-level economic performance. Government policy makers should therefore develop incentives to encourage investments in innovation during recessionary periods, even when financial resources are strained. Economies that do not invest in innovation likely experience weakened competitive positions in world markets. Firms' investment in innovation during tough economic periods, can position their nations to compete more effectively as the world economy recovers.

Providers of consulting services also can use the information from our study to help firms understand the relationship between investment in innovation and performance. Managers may be reluctant to commit capital to innovation during periods of diminished firm performance; consultants should help them understand the importance of their consistent, strategic commitment to innovation during all phases of the business cycle, including descriptions of how innovation improves competitiveness and long-term performance.

Several limitations of this study also suggest avenues for further research. We conducted this study in a single region in Spain, which facilitated data collection. Firm managers were easily accessible and, by isolating the study to a single region, we minimized the number of extraneous variables. Additional studies should consider other regions in Spain or other countries and thereby explicate any differences in commitment to innovation during a recessionary period in the context of the national culture. In order to control for endogeneity issues, the use of longitudinal and panel databases is recommendable, more effort is required to build these kinds of databases. Finally, further studies of the relationship between resources devoted to innovation during a recession and financial performance in the post-recession period could prove to be very insightful.

Note

1. The Sistema Annual de Balances Ibéricos (SABI) database contains relevant information for 850,000 Spanish firms. It covers 31 percent of Spanish firms with more than nine employees and more than 50 percent of large firms.

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