OWNERSHIP AND THE CYCLICALITY OF FIRMS' R&D INVESTMENT

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ABSTRACT

In this paper we analyse the effect of ownership on the response of firms' R&D expenditures to the business cycles in the economy, using a panel dataset of Spanish manufacturing firms for the period 1990-2006. Following Aghion *et al.* (2012), we allow the impact of the business cycle on firms' R&D expenditures to depend upon credit constraints, but we extend their analysis by considering the moderating effect of different firms' ownership types. We find that firms' R&D spending is countercyclical but that credit constraints may reverse this countercyclicality, in line with previous results in the literature. However, our findings indicate that these results are moderated by firms' ownership. In particular, in the case of firms that are family owned and firms that are group affiliated the responsiveness of R&D to the business cycle is considerably less dependent on being credit constrained, especially during recessions.

Keywords: R&D investment, business cycle, credit constraints, ownership.

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1 INTRODUCTION

The question on whether innovation activities exhibit a cyclical pattern over time has recently received increased attention in the literature. Although different approaches have been used, a mainstream has been based on the opportunity cost theory (Bean, 1990; Hall, 1991; Aghion and Saint-Paul, 1998, among others). According to this approach, since firms' resources are limited, devoting resources to productivity-enhancing activities, such as R&D investments, implies detracting resources from current production, that is, R&D activities are costly in terms of the forgone current output. Given that during economic downturns the revenues from production activities decrease, the opportunity costs of R&D will be low in recessions. Thus, the opportunity cost theory states that during recessions it will be optimal for firms to devote more resources to R&D activities, so that one may expect R&D investments to be countercyclical.

However, aggregate data have repeatedly documented that R&D is procyclical. For instance, Fatas (2000), Barlevy (2007), Comin and Gertler (2006) and Walde and Woitek (2004), among others, examine aggregate data and find that R&D expenditures show a procyclical pattern with respect to aggregate output in the US and other G7 countries.

Motivated by such aggregate evidence, a number of papers have come to devise theoretical models to reconcile the opportunity costs theory with the observed procyclicallity of aggregated R&D investments. Two prominent papers, using different perspectives, are Barlevy (2007) and Aghion *et al.* (2012). The work of Barlevy (2007) provides an explanation to the procyclicality of R&D which is based on the existence of dynamic spillovers from innovations: because current innovations benefit other firms later in time (due to imitation or improvements on previous innovations by competitors), firms incentives to innovate are based on short-term benefits. This implies that firms undertake more R&D in booms in order to capture the higher discounted present value of the profit they expect to earn if successful. That is, due to dynamic externalities, firms are short-sighted, chasing short-run profits at the expense of intertemporal substitution, engaging in too little R&D during recessions.

Aghion *et al.* (2012) present a theoretical model where credit market imperfections prevent firms from innovating and reorganizing in recessions. In their paper, there are two main arguments for R&D to be countercyclical. On the one hand, the Schumpeterian view of business cycles, according to which recessions prompt a cleansing mechanism for correcting organizational inefficiencies that encourages firms to reorganize, innovate or reallocate resources to new markets (Schumpeter, 1939). On the other hand, they use a direct application of the economic concept of opportunity costs, as explained above. However, according to Aghion *et al.* (2012), the previous arguments for the countercyclicality of R&D are only expected to work if firms are not credit constrained. When this is not the case, R&D investment is expected to be less countercyclical or even to become procyclical. The reason is that if external financing is limited, credit constrained firms should rely more on internal funds, which are very much related to firms' current earnings and the capacity to generate cash flows, variables that usually move with the business cycle.

Recent empirical evidence on the cyclicality of R&D investments, testing the opportunity cost theory with credit constraints and using firm level data, are provided by Aghion *et al.* (2012) and López-García *et al.* (2012). These two studies analyze the impact of the business cycle, measured as firms' sales growth, on firms' R&D, taking into account credit constraints. The findings of these two studies indicate that firms' R&D investments are countercyclical, but that when firms are credit constrained this countercyclicality of R&D is reversed. At the industry level, the works of Barlevy (2007) and Ouyang (2011) provide evidence on the procyclicality of R&D investments using panel data of US manufacturing industries.

However, this recent literature on the cyclicality of R&D investments, although acknowledging the importance of credit constraints, has not taken into account the role of the ownership structure of the firm as a likely moderating factor influencing the pattern of R&D investments over the business cycle. The way finance is supplied by owners to firms is likely to differ among different types of owners. In addition, according to the corporate governance and agency theory literature, the separation of ownership and control within the firm may result in a conflict of interests, due to the informational asymmetries between owners and managers and their different goals, that condition the way in which decisions on the allocation of resources are taken within the firm (Jensen and Meckling, 1976).

Therefore, we argue that the sensitivity of R&D investments to the business cycle is also likely to depend upon firms' ownership structure. In particular, we claim in this paper that different types of ownership may contribute to alleviate the effect of credit constraints on the cyclicality of firms' R&D by providing access to internal resources, other than the short-term generated cash flow, in order to finance their R&D investments. To the best of our knowledge, no systematic investigation has been conducted on the effects of the type of firms' ownership on the response of R&D investments to changes in the business cycle. The purpose of this paper is to fill this gap.

More precisely, the aim of this paper is to provide empirical evidence on the impact of the business cycle on firms' R&D spending, taking into account the ownership structure of firms. For this purpose, we explore whether different ownership structures, implying different firm financial dependency and different ways to decide on the allocation of internal resources, moderates the impact of the business cycle on R&D spending, taking into account firms' credit constraints. To focus on the role of ownership, we distinguish among three different ownership structures, namely, firms that are family owned, firms that are group affiliated, and firms with public capital participation.

We use a panel data for Spanish manufacturing firms provided by the Survey of Business Strategies (*Encuesta sobre Estrategias Empresariales*, ESEE henceforth) for the period 1990-2006. In order to capture the business cycle we use a micro level approach, that is, we try to identify idiosyncratic shocks to firms, which we proxy using firms' sales growth, following Aghion *et al.* (2012), among others.

The contribution of this paper to the related literature is twofold. First, as pointed out above, we extend the approach of Aghion *et al.* (2012) and López-García *et al.* (2012) to investigate the moderating effect of ownership on the relationship between the business cycle and firms' incentives to invest in R&D, taking into account credit constraints.

Second, we explore the existence of asymmetries in the sensitivity of firms' R&D spending to the business cycle, that is, we investigate whether R&D spending responds differently depending on whether the firm is facing favorable economic conditions, as compared to situations of less favorable market conditions. According to the opportunity cost theory with financial constraints, the model of Aghion *et al.* (2012) predicts that credit constraints interact with sales' growth in an asymmetric way over the business cycle, so that a tightening of credit constraints reduces the firm's R&D investment more in a downturn than in an upturn. Evidence on the existence of an asymmetric response of R&D investments to the business cycle may be found in Aghion *et al.* (2012) and Ouyang (2011).

The analysis of Spanish manufacturing firms offers an interesting context for several reasons. First, an important proportion of Spanish manufacturing firms are small and medium size firms, which are particularly prone to be hit by credit constraints. Second, many Spanish firms are owned by family members who may contribute to finance the firm with their own capital if required, especially when economic conditions deteriorate. Third, during the analyzed period, 1990-2006, the Spanish economy experienced a number of business cycle fluctuations. In 1992 Spain experienced a considerable decline in economic activity, which in 1993 resulted in a negative rate of real GDP growth, the worst recession of the last decades (disregarding the current one). Since 1994 the Spanish economy grew at quite favorable rates, reaching rates of growth of 4.5 percent in 1998, 4.7 percent in 1999, and 5.1 percent in 2000. Since 2001 and up to 2006 the Spanish economy has been growing at more moderate rates, ranging from 2.7 percent in 2002 to 4 percent in 2006. The long span of our data set, running over a period of seventeen years, allows us to analyze how firms' R&D investments responded to the business cycles during this period. All these characteristics make the Spanish data especially relevant for the study of R&D cyclicality.

To anticipate our results, we obtain that, controlling for firm and market characteristics, among other factors, there is a role for ownership in moderating the impact of business cycles in inducing firms' R&D spending. Our results suggest that firms' R&D spending is countercyclical when firms do not face credit constraints, but that credit constrained firms react in a less countercyclical (or even procyclical) way to the business cycle. These results are consistent with the findings in Aghion *et al.* (2012) and López-García *et al.*

(2012). More interestingly, our findings also indicate an asymmetric response of R&D to the business cycle, so that the sensitivity of R&D to credit constraints is especially relevant in recessions, and shows less responsiveness during upturns, in a similar way to the existing empirical literature (e.g., Aghion *et al.*, 2012, and Ouyang, 2011). However, and this is the main novelty of our work, our results indicate that under some ownership structures the procyclical role of credit constraints in R&D investments may not operate. In particular, we find that in the case of firms that are family owned and firms that are group affiliated the responsiveness of R&D to the business cycle is considerably less dependent on being credit constrained, and that, especially during recessions, R&D spending remains countercyclical for these firms. In the case of firms with public capital participation, however, the obtained results seem to suggest that the response of R&D to sales growth during the business cycle is not dependent on credit constraints.

Our findings suggest some policy implications for innovation policy. On the one hand, acknowledging that R&D is a long-run productivity enhancing activity, the procyclical pattern of R&D spending for those firms that are credit constrained may be considered as evidence of how recessions affect economic growth, suggesting a role for policy intervention, such as countercyclical R&D subsidies, or greater stabilization policies, especially oriented towards supporting credit constrained firms or firms more dependent on external finance. On the other hand, our findings also highlight the importance of ownership in moderating the impact of credit constraints on the responsiveness of R&D to the business cycle, and thus in alleviating the negative impact of recessions on the R&D spending of credit constrained firms. This implies that the expected effect of any given innovation policy is dependent on the ownership structure of firms and, in particular, that less policy instruments are likely to be required for those firms with an ownership structure that allows them more easily to rely their R&D spending on internal resources.

The rest of this paper is organized as follows. Section 2 establishes the theoretical framework leading to our estimation hypotheses. Section 3 provides a description of our empirical model, data and variables, and presents a descriptive analysis of the main relationships of interest between the variables. Section 4 reports and discusses the econometric results and, finally, section 5 concludes.

2 THEORETICAL FRAMEWORK AND HYPOTHESES

2.1 *The cyclicality of R&D and credit constraints*

The theoretical framework guiding our empirical analysis on the links between the business cycle and firms' R&D investments is based on Aghion *et al.* (2012). Differently to most of previous papers on the cyclical behavior of R&D investments, they provide a theoretical model with very precise predictions about the effects of the business cycles on this type of investments. Their work provides a theoretical framework reconciling the arguments sustaining that R&D investments should be countercyclical, with empirical studies which have extensively documented that R&D investments behave procyclically.

The theoretical work in Aghion *et al.* (2012) is particularly interesting for the aim of our paper. On the one hand, regarding the central question on whether and how the business cycle affects R&D investments, these authors distinguish between two different groups of firms, depending on whether or not firms face credit constraints, and between two different sides of the business cycle, downturns and upturns. On the other hand, their work derives specific implications for the empirical work and provides empirical evidence for the predictions, using firm-level French data.

In addition, Aghion *et al.* (2012) constitutes for us a unique framework for the study of the relationship between ownership and investment in R&D. As Minetti *et al.* (2011) and Munari *et al.* (2002) have noticed, the theoretical literature on ownership structure and innovation is still underdeveloped and the empirical evidence is scant (Bushee, 1998; Eng and Shackell, 2001; Aghion *et al.*, 2009). In this paper, in answering the question about how different types of firms adjust their investment in R&D during the business cycle, we consider that it is crucial to take into account the role of credit constraints. Our aim is, then, analyzing the relationship between ownership, business cycles and R&D investments. In fact, recent papers have suggested that further progress in the literature linking corporate governance and ownership with R&D should advance towards integrating the theory of R&D investment with models of agency and financial constraints (Hall, 2002; O'Sullivan, 2005; Lhuillery, 2011; Driver and Coelho Guedes, 2012).

There are two main arguments for R&D spending to be countercyclical. First, according to the Schumpeterian view of business cycles, recessions prompt a cleansing mechanism for correcting organizational inefficiencies that encourages firms to reorganize, innovate or reallocate resources to new markets (Schumpeter, 1939). Second, according to the economic concept of opportunity costs, R&D spending should increase in recessions. Since investment choices are driven by opportunity costs, and the opportunity cost of long-term innovative investments instead of short-term capital investments is lower in recessions than in booms, when firms enjoy an upturn they will rather allocate their resources to current production than to reorganization or innovation activities. The opposite will happen if firms suffer a downturn

(Bean, 1990; Gali and Hammour, 1992; Hall, 1993; Aghion and Saint-Paul, 1998; Bloom 2007).

However, the previous arguments for countercyclicality of R&D are only expected to work if firms are not credit constrained, that is if they do not face problems for borrowing funds to innovate and reorganize. When this is not the case, R&D investment is expected to be less countercyclical, or even to become procyclical (Aghion *et al.*, 2012). The reason is that if external financing is limited, credit constrained firms should rely more on internal funds, which are very much related to firms' current earnings and the capacity to generate cash flows, variables that usually move with the business cycle. Thus, our first two hypotheses derive directly from the main two theoretical predictions in Aghion *et al.* (2012) regarding the impact of the business cycle on firms' incentives to invest in R&D, and are the following:

Hypothesis 1: R&D is countercyclical for firms that are not credit constrained. However, R&D is more procyclical for those firms that are credit constrained.

Aghion *et al.* (2010, 2012) emphasize that, not only credit constraints inhibit firms from innovating and reorganizing, but also that this obstacle has more severe effects during downturns, when firms face both a reduction in current earnings and in the ability to borrow. R&D investments are expected to be especially hit by these two factors, given that financial institutions are more reluctant to provide funds in recessions for long-term R&D investments *versus* short-term capital investments. Lenders of funds consider that innovation is a risky activity, that information about projects for new technologies tend to be opaque, and that innovation requires long-term projects involving large costs that are sunk in nature (Stiglitz, 1987; Martin, 1993; Cohen and Klepper, 1992, 1996a, 1996b; Åstebro, 2002, 2004; Máñez et al., 2009). For all these reasons, R&D investments should be even less countercyclical (or even to become procyclical) in recessions for firms facing credit constraints, given that financial conditions for credit constrained firms worsen during recessions.

Hypothesis 2: There is an asymmetric effect of credit constraints on R&D along the business cycle, that is, credit constraints reduce firms' R&D more in a downturn than in an upturn.

2.2 *The role of ownership*

The above framework, linking the business cycle with firms' R&D investments and credit constraints, may be extended in a natural way to include the moderating effect of the firms' ownership structure. Firms' ownership structure is important in the analysis of the cyclicality of R&D because it determines the way in which investment decisions are taken within the firm and, thus, it may help to explain the degree to which credit restrictions impact on R&D adjustments during the business cycle.

Our rationale to claim that different forms of firms' ownership may contribute to soften the effect of credit constraints is twofold. First, in some cases, owners bring firms the possibility of having access to internal finance for their R&D projects, when external credit is difficult. Credit constraints in recessions are expected to be fiercer for firms without access to any type of internal financial source, which are obliged to resort to external financial markets for lending. The way firms finance their investments, particularly risky investments such as R&D, may be highly dependent on the access to internal capital. Internal financial resources may help firms to provide protection against cash follow volatility and ensures that R&D investments are maintained even during bad times (O'Brien, 2003, p. 420). Secondly, the corporate governance and the agency theory literature establish that the separation of ownership and control in the firm may result in a conflict of interests due to the informational asymmetries between owners and managers, and their different goals within the firm (Jensen and Meckling, 1976). These conflicts may result in different preferences between owners and managers for the allocation of internal sources. In addition, one may expect different types of owners to have different preferences in this allocation of resources, in general, and in the amount of R&D investments, in particular (Kochhar and David, 1996). Therefore, we argue that the willingness to allocate available internal funds to R&D investments is contingent on who owns the firm, especially when facing adverse economic conditions.

In our analysis we distinguish among three types of firms according to their ownership structure, namely, family owned firms, group-affiliated firms, and firms with public capital participation. Under these three different ownership structures, and for different reasons, firms may be able to reduce their financial dependency, especially during economic downturns, by having access to internal funds, thereby reducing or alleviating the impact of credit constraints on R&D investments.

Family owned firms

Family owned firms are those in which founders and their family members possess a large proportion of equity ownership and, usually, hold prominent positions in the top management team of the firm.

In family owned firms, since the owners' wealth is aligned with the firm's wealth, family members can contribute with their own capital if required. Thus, in family owned firms there exists the possibility of having access to these internal owners' funds. In addition, family members are usually unwilling to rely on external sources to obtain necessary resources for risky projects such as R&D since they are eager to keep and ensure control over the firm (Mishra and McConaughy, 1999). Then, access to internal funds is likely to be easier within these firms, especially when credit conditions deteriorate.

In addition to the easier access to more internal funds in family owned firms, the ownership structure of these firms may contribute to decide in favor of allocating these resources to R&D investment, if required. In accordance with the corporate governance theory, family members with executive positions within the firm have access to internal information and may influence to a great extent firm's decisions over how internal financial resources are allocated among competing demands (Kim *et al.*, 2008). In addition, since in these firms owners may easily monitor and influence managerial decisions, agency problems arising from the separation of ownership and management functions are very much mitigated (Jensen and Meckling, 1976). To the extent that family wealth is closely linked to firm wealth, family members have great incentives to maximize the firm's value (Anderson *et al.*, 2003). Often, family members hope their descendants inherit the firm control rather than consume current wealth (Casson, 1999). Thus, family members have longer investment horizons, as compared to other type of owners, and they may be more willing to decide in favor of long-term projects, such as R&D, that help to ensure the survival of the firm.

Thus, following the above discussion, due to lower dependence on external funds and lower agency problems, we expect that being a family owned firm reduces the degree to which credit constraints force firms to rely on short-term sales (cash-flow) to maintain R&D investments during the business cycle (that is, it reduces the procyclicality of R&D in financially constrained firms). Hence, we hypothesize:

Hypothesis 3: *Being a family owned firm reduces the procyclicality effect of financial constraints on R&D, and in particular during downturns.*

Group affiliated firms

A business group may be defined as "*a multi-company firm that transacts in different markets and does so under entrepreneurial and financial control*" (Leff, 1978, p. 662). Thus, it consists on a group of formally independent firms under a common financial and administrative control (Chang, 2003, p. 238).

In accordance with Chang and Hong (2000), group-affiliation allows firms to share group-wide resources and internal business transactions. In this line, several studies have confirmed the positive effect of group-affiliation on the financial performance of affiliated firms (e.g., Yiu *et al.*, 2005; Keister, 1998; Ma *et al.*, 2005). By sharing and transferring resources within the business group, affiliated firms can invest more than they can afford, thereby overcoming credit constraints (Hoshi *et al.*, 1991). In other words, group-affiliation allows the formation of an *internal capital market* that may partially replace the external capital market (Gertner *et al.*, 1994). Thus, as pointed out by Mahmood and Mitchell (2004), business groups may act as venture capitalists for firms that lack own funds or external sources for funding.

In addition, and according to Kim *et al.* (2008), group-affiliated firms may possess the same information and control advantages on internal financial resources as family owned firms. The reason is that these groups tend to perform as a sort of intertwined ownership structure where one group-affiliated firm may own another group-affiliated firm and *vice versa* (Joh, 2003). As a consequence, financial decisions in the group-affiliated firm may be driven by group-wide considerations, where business activities and strategies are coordinated. Thus, group-affiliated firms may take into consideration investment projects of other group members, including R&D.

Following the above line of reasoning, we claim in this paper that, when economic conditions are deteriorating, i.e., during downturns, R&D performing firms that are members of larger organizations have the possibility to maintain their R&D investments levels by having access to internal group resources, driven by group-wide considerations. Hence, we also expect in this case the sensitivity of R&D spending to the business cycle to be less dependent on being financially constrained for group-affiliated firms, especially during recessions. Thus, we hypothesize:

Hypothesis 4: Being a group-affilliated firm reduces the procyclicality effect of financial constraints on R&D, especially in downturns.

<u>*Firms with public capital participation*</u>

Firms with public capital participation are firms in which government institutions possess a proportion of the firm's equity ownership.

Firms with public capital participation may be more able to maintain their investment in R&D, even under credit constraints, to the extent that they may expect to have the financial support of government funding, if needed.

The willingness of governments to provide funds to these firms is based on the fact that government's goals and long-term policy choices are usually beyond the specific aim of short-term profit maximization. This long-term perspective may have a positive effect on the promotion of R&D investments, and, in turn, on the impact of the business cycle on R&D for these firms. Frequently, public-participated firms may have access to public funds through privileged channels, thus, compensating also for possible capital market imperfections (Hyytinen and Toivanen, 2005).

However, there are two characteristics of this type of ownership that could operate against the provision of funds for R&D in downturns. First, in tough macroeconomic conditions, governments may be primarily urged to cut down on expenses and reduce equity injections across the board as part of the general goal of maintaining public deficit into acceptable margins. Second, unlike family owners and group affiliated firms, outside owners, in general, face greater informational and control disadvantages (Willianson, 1975). Agency problems may be relevant in this case, since the government, in general, is less likely to monitor the decision-making processes of firms, particularly in the short-term (Kochhar and David, 1996). Over the business cycle, managers of public-participated firms may be more focused on short-term goals and be driven by career concerns that make them more risk-averse, thus deviating resources from R&D spending (Aghion *et al.*, 2009).

Thus, in the case of firms with public capital participation two opposite arguments may affect the impact of the business cycle on R&D spending. On the one hand, public-participated firms may count, in principle, on the government as an important alternative source of funds for their R&D projects. However, agency costs problems and budgetary cuts may operate against these alternative sources of funds during downturns, making firms'

R&D projects dependent on their short-term performance and own internal sources. Hence, in this case we hypothesize:

Hypothesis 5: Being a firm with public capital participation has an ambiguous moderating effect on the procyclicality of R&D under credit constraints, in particular in downturns.

3 EMPIRICAL MODEL, DATA AND VARIABLES: DESCRIPTIVE ANALYSIS

3.1 *Empirical model, data and variables*

The data used in this paper are drawn from the *Survey of Business Strategies* (ESEE, henceforth), for the period 1990-2006. This is an annual panel survey sponsored by the Spanish Ministry of Industry and carried out since 1990 that is representative of Spanish manufacturing firms by industrial sectors and size categories. The sampling procedure is the following. Firms with less than 10 employees were excluded from the survey. Firms with 10 to 200 employees were randomly sampled, holding around 5 percent of the population in 1990. All firms with more than 200 employees were requested to participate, obtaining a participation rate of 70 percent in 1990. Important efforts are made to minimize attrition and to incorporate annually new firms with the same sampling criteria as in the base year, so that the sample of firms remains representative over time.[1]

The ESEE provides exhaustive information at the firm level on a number of issues, including information on R&D expenditures, sales, the ownership type of the firm and a comprehensive set of quantitative variables of the firm's balance sheet. The main variables implied in the analysis are

[1] See http://www.funep.es/esee/ing/i_esee.asp for further details.

summarized in our estimation equation, in which we regress R&D spending on firm's sales growth and its interaction with credit constraints as follows:

$$\begin{aligned}\log RD_{it} = \alpha + \beta \Delta \log s_{it} + \theta CC_{it} + \gamma\, CC_{it} \cdot \Delta \log s_{it} \\ + \sum_{w=1}^{3} (\beta_w \Delta \log s_{wit} + \theta_w CC_{wit} + \gamma_w CC_{wit} \cdot \Delta \log s_{wit}) \quad (1) \\ + \log s_{it} + \mu Z_{it} + \varepsilon_{it}\end{aligned}$$

In (1), RD_{it} stands for the (real) R&D spending of firm *i* in period *t*, $\Delta \log s_{it}$ represents firm *i*'s sales growth during year *t*, and CC_{it} is a dummy variable taking value 1 if the firm is credit constrained (as explained below). The fourth term in (1), replicates the basic set of variables (sales growth, the *CC* dummy and the interaction of *CC* with firms' sales) for the three (w=3) ownership categories of firms under consideration, that is, for family owned firms, group affiliated firms, and firms with public capital participation. Finally, the estimation equation includes the level of sales of the firm, $\log s_{it}$, to account for firms' size effects, as well as a vector of control variables (Z_{it}) including the firm's age and a full set of year and industry dummies.

As implied by equation (1), we use a micro level approach to identify idiosyncratic shocks to firms, which we proxy for using firms' sales growth, following Aghion *et al.* (2012), among others. To check the extent to which this firm level measure mirrors the macro-business cycles in Spain during the observed period, we compare in Figure 1 this firm level information with the GDP evolution in Spain from 1990 to 2006. In particular, we show in this figure the annual average of manufacturing firms' sales calculated from the ESEE data as well as annual values of the GDP at a macro level. Both variables have been previously filtered using the Hodrick-Prescott filter, as is standard in the literature (see, e.g., Jan-Benedict *et al.*, 2011), to separate the cyclical component of these variables from their time trend. Figure 1 shows the similar evolution of our (previously aggregated) estimation data and the

GDP in the Spanish economy. In estimation, however, the firm level growth variable, $\Delta \log s_{it}$, is able to capture the heterogenous firm performance in a more accurate way.

[Figure 1 around here]

3.1.1 The '*credit constrained firm*' variable

The variable proxying for credit constrains, CC_{it}, deserves special attention. In the literature on financial constraints there is neither a unique nor a universally available measure of credit constrains. Since the seminal work of Fazzari *et al.* (1988), the literature identifies several sources of firms' credit constraints. On the one hand, variables capturing firm characteristics may be important to the extent that they interfere in the transparency of the firm from the viewpoint of the creditor (see, for example, Bester, 1985; Gilchrist and Himmerlberg, 1995; Reeb et al., 2001; Anderson et al., 2003; Crespi and Scellato, 2007, and Coluzzi et al., 2008). For example, this literature predicts that small and young firms, with higher default risk and uncertainty about future returns from investments, will suffer from higher costs of financing. On the other hand, credit constraints have been measured using variables defining the degree of the firm exposure to external finance, such as debt ratios or financial burden (see, e.g., Bernanke *et al.*, 1996, or Hernando and Martínez-Carrascal, 2003).

In practice, empirical work relies on available data, often highly specific to the data source being used in each case. For instance, both Reeb *et al.* (2001) and Anderson *et al.* (2003) use credit ratings from *Moody's* and *S&P* to measure the default risk premium as a proxy for the cost of debt financing. Using this proxy they stress that credit should be negatively related to the cost of debt as firms with lower rating generally have a higher cost of debt financing. In addition, Crespi and Scellato (2007) use the degree of leverage as a proxy for financial constraints. Bovha-Padilla *et al.* (2009) use an indicator of credit constraints reported by the firms in the CIS (Community Innovation Survey) data. Lin *et al.* (2011) use an estimation of the shadow value of external funds (or shadow cost associated with raising new external financing) as a measure of external finance constraints. Others, such as Aghion *et al.* (2012), rely on data on firms' defaults on trade credits (or *payments incidents*) reported by French Banks, and López-García *et al.* (2012) use information provided by firms on whether or not they have faced important lack of finance from external sources during the two previous years.

In our sample, around 97 per cent of firms are not listed in the stock market, what gives an idea about the role played by financial institutions and, specially, the banking system, as firms' external finance providers. In fact, in Spain, similarly to Italy, bank loans are the most common form of external finance and constitute the bulk of firms' financial debt (Schiantarelli and Sembenelli, 2000). Therefore, the cost of debt financing is likely to be one very important source of credit constraints for Spanish manufacturing firms.

In this paper we rely on information of the firm's balance sheet provided by the ESEE to construct our dummy variable CC_{it} in (1), which identifies credit constrained firms. To construct this variable we have proceed in three steps, as follows. First, using information from the firms' balance sheet, we have constructed a variable that aims at capturing the cost of the long-term debt (debt to more than a year) that firms face when asking for credit to the banking system during the current year. In particular, the variable has been defined as the ratio of the total cost of the long-term debt of the firm over the total volume of the long-term debt. The cost of the long-term debt is measured as the unit cost of the debt the firm has acquired from credit institutions during the year multiplied by the volume of this type of debt, plus the corresponding measure for the debt from 'other' long-term creditors. We may write this variable ($DCOST_{it}$) as follows:

$$DCOST_{it} = \frac{\left(cost_{it}^{DCI} \cdot DCI_{it}\right) + \left(cost_{it}^{DOther} \cdot DOther_{it}\right)}{DCI_{it} + DOther_{it}} \tag{2}$$

where *DCI* stands for the long-term debt with credit institutions and *DOther* stands for the long-term debt with other creditors.

Second, we have constructed a variable that indicates if $DCOST_{it}$ deviates from the annual average value calculated over the whole sample of firms in the Spanish manufacturing sector for a given year (N_t), that is:[2]

$$Dev\_DCOST_{it} = DCOST_{it} - \sum_i \frac{DCOST_{it}}{N_t} \tag{3}$$

Finally, we define the variable CC_{it} in (1) as a dummy variable taking value 1 if the firm is credit constrained, as follows:

$$\begin{cases} CC_{it} = 1 \quad if \quad Dev\_DCOST_{it} > 0 \\ CC_{it} = 0 \quad if \quad Dev\_DCOST_{it} \leq 0 \end{cases} \tag{4}$$

3.2 *Descriptive analysis*

Table 1 displays basic descriptive statistics regarding both the composition of the estimation sample and the average values of the main variables of interest in the analysis. After removing missing values, we are endowed with an estimation sample of 20,900 observations corresponding to 3,361 firms

[2] This guaranties that we are not mixing other effects such as, for instance, more countercyclical macroeconomic policies that could imply a reduction of interest rates in downturns.

observed, in an unbalanced way, during our 17-years observation window. Regarding the ownership type of firms, around 46 percent of the observations correspond to family owned firms, around 26 percent to group affiliated firms, and about 2 percent are observations corresponding to firms with public capital participation. Thus, jointly, the percentage of observations belonging to one or another of these categories is quite considerable in our sample.

With regards to the percentage of credit constrained observations, we observe that, for the whole sample, around half of the sample observations are classified as credit constrained (near 51 percent as against 49 percent which are not constrained). The distribution of these percentages is somewhat more asymmetric when we take into account the ownership type of the firms. In particular, for the sample of family owned firms, around 60 percent of observations are classified as credit constrained, whereas near 41 percent are not. In the case of group-affiliated firms, only around 30 percent are credit constrained and, finally, for those firms with public capital participation the percentage of credit constrained observations is around 25 percent.

[Table 1 around here]

Table 1 also provides information on firms' engagement in R&D activities. For the whole sample, we observe that 70 percent of large firms undertake R&D activities, while only around 19 percent of SMEs do so.[3] This

[3] Although the standard classification of SMEs establishes the bound to distinguish SMEs from large firms in 250 employees, we have defined SMEs as those firms with less than 200 employees and large firms as those with 200 or more employees, in order to be consistent with the different sampling procedure followed by the ESEE for these two size groups. Reported values of the variables of interest throughout the

is not surprising since, as widely acknowledged, the percentage of large firms engaged in R&D activities is much larger than that of SMEs. The figures in Table 1 suggest, on the one hand, that non-credit constrained observations are associated with slightly higher percentages of R&D performing firms, and, on the other hand, that the percentage of firms engaged in R&D is higher in the categories of group-affiliated firms and firms with public capital participation. This latter remark is particularly clear in the case of SMEs with public capital participation, in which case positive R&D observations amount to around 43 percent as compared with around 18 percent for the whole sample of firms of this size group.

The figures of the R&D-to-sales ratios in Table 1 suggest that, conditioned on doing R&D, the average values of these ratios are dependent on the type of ownership. In particular, both family owned firms and group-affiliated firms that are credit constrained, have higher R&D-to-sales ratios than non-credit constrained firms in their corresponding ownership category, whereas for the group of firms with public capital participation the figures suggest an opposite pattern.

Finally, the sign of the correlation between the R&D-to-sales ratios and the firms' sales growth, that is, the pro-cyclicality or counter-cyclicality of R&D intensities, seem to depend both on the fact of being credit constrained or not, and on the type of firm's ownership. As suggested by Aghion *et al.* (2012), the negative sign of this correlation for the whole sample reverses to positive when

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paper have been weighted accordingly. In particular, we have upgraded the number of small and large firms in the survey to Spanish manufacturing population proportions (in the ESEE firms with less than 200 employees account for the 5% of the whole population of firms in this size group, and firms with more than 200 employees represent around a 70% of the population of firms in this size category).

we consider the sample of credit constrained firms. However, this correlation is negative for family owned firms regardless of being credit constrained or not, whereas the correlation is positive for group affiliated firms and for public capital participated firms.

Figures 2 to 6 provide a first illustration of the cyclicality of R&D and the extent to which this may be dependent upon credit constraints and firms' ownership type. The figures show the *lowest smooth curve* of the relationship between the firms' R&D-to-sales ratios and sales growth for different groups of firms, as specified in each figure. Figure 2 shows, for the entire sample of firms, a negative relationship between R&D and the business cycle, in particular in the first half of the horizontal axis, corresponding to negative sales growth rates or downturns. In contrast, the sample of credit constrained firms, represented in Figure 3, suggests a positive relationship between R&D and sales growth.

However, if we focus on credit constrained firms and distinguish among ownership types (Figures 4 to 6), different patterns emerge. In the case of family owned firms, for example, the effect is highly asymmetric between economic downturns and upturns. In particular, R&D in these firms seems to behave clearly countercyclical during downturns and, in contrast, clearly procyclical during upturns. A similar pattern may be observed in Figure 5, corresponding to credit constrained group-affiliated firms. Finally, Figure 6 illustrates a different pattern for those credit constrained firms with public capital participation, since the relationship between R&D and sales growth behaves procyclical during downturns and countercyclical during economic upturns.

[Figures 2 to 6 around here]

Thus, although at a descriptive stage, it seems that both the consideration of credit constraints and firms' ownership structure may shed light into the discussion on the cyclicality of firms' R&D spending. In addition, our descriptive graphical analysis suggests a considerable degree of asymmetry in the response of R&D spending to the business cycle, namely, in the presence of credit constraints firms do not respond to economic downturns in the same way than to economic upturns. This asymmetry is also dependent on the ownership structure of the firm.

In the next section, we present our econometric results in order to qualify more accurately these preliminary findings.

4 ECONOMETRIC RESULTS

In our estimation equation, as presented in expression (1) above and repeated here for the sake of exposition, we regress R&D spending on firm's sales growth and its interaction with credit constrains as follows:

$$\begin{aligned}\log RD_{it} = \alpha + \beta \Delta \log s_{it} + \theta CC_{it} + \gamma\, CC_{it} \cdot \Delta \log s_{it} \\ + \sum_{w=1}^{3} (\beta_w \Delta \log s_{wit} + \theta_w CC_{wit} + \gamma_w CC_{wit} \cdot \Delta \log s_{wit}) \quad (1) \\ + \log s_{it} + \mu Z_{it} + \varepsilon_{it}\end{aligned}$$

where the right hand side terms are defined as described in the previous section above. Our estimation method is a panel *Tobit maximum likelihood* estimator that accounts for the high number of zeros in our R&D variable (around 68 percent).

The first set of estimation results are presented in Table 2. In estimation we proceed by including sequentially the relevant variables in our analysis. Thus, we first estimate a basic specification (first column of Table 2) in which we regress R&D on firms' sales growth and the full set of control variables (this is our benchmark specification). In column (2) we include both our dummy variable for credit constraints, CC_{it}, and the interaction of this dummy with sales growth. Finally, in column (3) we include the corresponding set of variables for family owned firms, for group-affiliated firms and for public-participated firms.

[Table 2 around here]

According to the estimation results for our benchmark specification, which are provided in column (1) of Table 2, our parameter of interest, β, is negative and highly significant, indicating that, overall, without distinguishing between credit constrained and non-credit constrained firms, firms' R&D effort is countercyclical. This is consistent both with the Schumpeterian view and with the opportunity costs hypothesis.

However, this basic specification does not take into account the role of credit constraints in shaping the link between the business cycle and R&D investments. Thus, for testing Hypothesis 1 in this paper we also estimate a second specification whose results are reported in column (2). Based on the theoretical predictions of Aghion *et al.* (2012), we expect R&D investment to be countercyclical for firms that are not credit constrained ($\beta < 0$). However, credit constraints are expected to turn this relation more procyclical ($\gamma > 0$). The results in the second column of Table 2 support this hypothesis, as the coefficient on sales growth is negative and highly significant, and the estimated effect of the interaction with the credit constraints variable is positive and also highly significant.

Next, in column (3), in order to test Hypothesis 3 to 5, that is, to analyze the potential role of ownership types in shaping the relation between the business cycle and R&D investments, we introduce into the model specification the variables for credit constraints and its interaction with sales growth for the three categories of ownership. For doing so, we have constructed three dummy variables accounting for firms family owned (FO_{it}), group-affiliated firms (GA_{it}), and firms with public capital participation (PC_{it}), respectively, and, then, we have interacted these dummies with the variables of interest in the analysis. The estimation equation is, in this case, the full model specification provided in (1). Notice that, in this latter case, the estimated coefficients for variables crossed with the dummies of ownership have to be interpreted as differential effects with respect to the estimates for the category of '*other*' firms than family owned, group-affiliated or public-participated firms, that is, the estimates of β and γ in equation (1) above.

With this last set of results in Table 2 we are interested in examining whether or not the result that R&D is more procyclical for firms that are credit constrained is weaker for our specific ownership types. If the latter is true, we expect the estimated coefficients of the sales growth for credit constrained firms in each ownership category (that is, the interactions of the dummies for ownership with the dummy for credit constraints and sales growth) to be negative and statistically significant. Our results confirm that this is the case for credit constrained family owned firms and for credit constrained group-affiliated firms. In the case of firms with public-capital participation, however, we do not obtain significant differential effects. In fact, although it is not statistically significant, the sign of the estimated coefficient in this latter case is positive. Thus, our results indicate that the procyclicality of R&D induced by credit constraints is soften for firms that are family owned or group-affiliated, although no differential effect with respect to the reference category is found in the case of firms with public-capital participation.

Some variables that render statistical significance in Table 2 (although they are not the core variables of interest in this paper) are the credit constraints dummy, the variable that controls for firm's size and the dummy variables for family owned firms and firms with public-capital participation. The coefficient for the credit constraints dummy is always negative and statistically significant, meaning that long-term investments such as R&D are negatively affected by credit conditions *per se* (previous evidence on this can be found in Hall, 2002, and López-García and Montero, 2010). The coefficient on the firm size variable (log of real sales) is positive and highly significant in all columns, meaning that larger firms invest more in R&D. Further, the positive and also highly significant estimates for both the dummy accounting for being a family owned firm and the dummy corresponding to firms with public capital participation, indicate that, other things equal, these types of firms invest more in R&D (being this effect for public participated firms approximately twice that of family owned firms).

The results indicating that both family owned firms and public-participated firms are likely to invest more in R&D than other type of firms is supported by the theoretical literature on the subject. In the case of family firms, the fact that they will be passed to future generations, make current owners to be long-term value maximizers (Casson, 1999; Anderson *et al.*, 2003) and, therefore, more willing to invest in long-term projects such as R&D. Regarding firms with public capital participation, they very likely hold a wider set of objectives rather than simple profit maximization, including, for instance, the production of a public good (Munari *et al.*, 2002; Molas-Galart and Tang, 2006) or the promotion of the national levels of R&D investment by means of specific R&D programs in firms with public capital participation.

[Table 3 around here]

The estimation results in Table 3 report the asymmetries of the estimated effects between economic upturns and downturns. For doing so, we have defined, first, a variable indicating whether the firm is facing an upturn or a downturn, measured as the deviation of each firm's sales growth from the average value of the firm's sales growth over the entire sample period (1990-2006). Then, a dummy variable for upturns, denoted by *Up*, is defined as taking value 1 or 0 if the firm's sales growth deviation in a given year is either positive or negative, respectively. The corresponding dummy for downturns, denoted by *Down,* is defined just in the opposite direction. We take as starting point the model specification corresponding to the last column of Table 2 and we interact sales growth (and all the variables involving sales growth) with these two dummies. This is our first approach to treat business cycle asymmetries (following Aghion *et al.*, 2012).

Alternatively, and as a robustness check, we further perform the analysis of asymmetric responses over the business cycle with two dummies corresponding to the macroeconomic cycle that have been constructed from the cyclical component of GDP (as described in Section 3). Following established practice in macro business cycle economics (Hodrick and Prescott, 1997; Jan-Benedict *et al.*, 2011), we consider that the economy is in a downturn when the GDP growth, calculated from the cyclical component of GDP, is negative (meaning that the economy grows less than its long-term trend) and in an upturn when it is positive.

Allowing for asymmetric effects over the business cycle allows us to discern whether the more procyclical behavior of R&D for credit constrained firms is due either to the fact that credit constraints make firms' own sales the source for R&D spending during downturns or, alternatively, that firms increase more their R&D investments in upturns when credit constrained. The answer to this question is in Table 3, which, independently of using the micro or the macro cycle indicator, confirms the qualitative results obtained in Table 2 but, further and even more importantly, indicates that these results hold especially during downturns. First, and for the '*other firms*' category, both the countercyclical effect for non-constrained firms and the procyclical effect for constrained firms hold statistically significant only during downturns. This suggests that it is during economic downturns that credit constraints explain the procyclical behavior of R&D. In addition, the differential impact of sales growth on R&D for family owned firms and for group-affiliated firms when they are credit constrained, only holds in periods of economic downturn (i.e., the estimates of the sales growth for credit constrained firms in these groups remains negative and statistically significant only during downturns). The magnitude of these estimated coefficients are larger than in column (3) of Table 2. Thus, for these types of firms, our results confirm our *Hypothesis 2* that the expected procyclical effect of credit constraints turns out to be asymmetric and only operative in downturns.

However, these results differ for firms with public-capital participation, since, in this case, neither in upturns nor in downturns the effect of sales growth for credit constrained firms adds any differential effect to the negative value of the coefficient obtained for non-credit constrained firms of this type.[4]

Table 3 adds further details to the general results of Table 2. In particular, in the cases of group-affiliated firms and firms with public-capital

[4] The signs of the estimated effects of sales when financial constrains exist, although non statistically significant, are positive during downturns and negative during upturns, thus suggesting the pattern already observed in Figure 6.

participation the countercyclicality of R&D for non-credit constrained firms appears not only during downturns, as in the category of 'other' and family owned firms, but also during economic upturns. In other words, in accordance to our estimation results, the opportunity cost hypothesis holds both during good and bad times for these firms, thus indicating that firms respond more negatively to the evolution of sales during upturns when they are group affiliated firms or firms with public-capital participation. With the macro cycle indicator of ups and downs (column (2)), the estimated signs are the same but statistically non-significant.

The estimated results for the control variables confirm the results already obtained in Table 2 that larger, family owned and public-capital participated firms have, on average, higher levels of R&D investment (the estimated coefficient for public-capital participated firms more than doubles the effect for family owned).

In Tables 4 and 5 we provide a summary of the total estimated effects of firm's sales growth on R&D. The figures in these tables have been built up using the estimation results of the final column of Table 2 and the first column of Table 3, and summing up all the estimated coefficients implied in determining the total effect of sales growth in each case. Those estimated coefficients that do not render statistical significance have been replaced by 0 in the corresponding sum. We provide the *p*-values for each of the estimated total effects.

[Table 4 around here]

A first clear result in Table 4 is that the countercyclical (and significant) behavior of R&D when firms do not face credit constraints may reverse when firms are credit constrained. Our reference category, corresponding to '*other*' firms than family owned firms, group affiliated firms, or firms with public capital participation, shows a final procyclical response of R&D since the differential positive effect of sales growth when firms face credit constrains even overcomes the initial negative effect for non-credit constrained firms. Thus, in this general case, our results support our *Hypothesis 1* and are consistent with Aghion *et al.* (2012). As stated above, family owned and group affiliated firms do not seem to follow this general pattern since, as stated in our *Hypotheses 3* and *4*, the procyclical effect induced by credit constraints is lower for these firms. In particular, the differential negative effect of sales growth for family owned firms and group affiliated firms when facing credit constraints cause the final effect of sales growth to be negative (-0.917 and -1.2 respectively), although these results do not achieve statistical significance. The final effect, then, would be accepted to be non statistically different from zero. The case of public-participated firms, as discussed in Tables 2 and 3, does not show any significant differential effect, thus we should accept for these firms the final procyclical effect that also applies to the category of '*other*' firms.

[Table 5 around here]

In Table 5 we proceed further to analyze the total effects of sales growth when we consider the possibility of asymmetric results in economic upturns and downturns (using our micro cycle indicator based on firms' sales growth, as discussed above). This table shows that, as observed in Table 3 above, the countercyclical results remain in almost all the cases for non-constrained firms. Non-credit constrained firms in the cases of group-affiliated firms and public-participated firms, differently to family owned firms and '*other*' firms, show a significant differential effect of sales growth during upturns, in the sense that R&D exhibits also in these periods a clear countercyclical behavior that, in the case of family owned and 'other' firms, only appears in downturns. The *p*-values for the estimated total effects in the case of group-affiliated firms show that the countercyclical result, actually, is only significant during upturns. If we focus now on credit constrained firms in Table 5, we observe that the asymmetry in the results are much more evident. In this case, the results during upturns do not deviate at all from the results for non-credit constrained firms. However, during downturn periods, credit constrains show the pattern already discussed above for Table 4. There is, however, a difference between Table 4 and Table 5, since the *p*-values in the last two columns of Table 5 allow us to accept now the statistical significance of the final estimated effects in almost all the cases.

In summary, our estimation results provide evidence on our *Hypothesis 1 and 2*, established following Aghion *et al.* (2012). In particular, we obtain that when firms do not face credit constraints, R&D spending is countercyclical and that it becomes less countercyclical, and even procyclical for those firms with credit constraints. Further, our results also provide support to our *Hypotheses 3 to 5* in the sense that firms' ownership type may determine to a great extent the role played by credit constrains in explaining the cyclical behavior of R&D. Finally, our findings also indicate the importance of differentiating the behavior of firms during upturns and downturns, since the role of credit constrains is crucial especially during downturns.

5 CONCLUDING REMARKS

In this paper we have analysed the impact of the business cycle on firms' R&D spending, taking into account firms' credit constraints and different forms of ownership structure. Our empirical approach has been based in Aghion *et al.* (2012), which we have extended to include the moderating role of ownership. The main rationale for including ownership in the analysis is that different ownership structures may contribute to alleviate the effect of credit constraints on the cyclicality of firms' R&D by providing access to internal resources in order to finance their R&D investments. Thus, our main point is that the sensitivity of R&D investments to the business cycle is likely to depend upon firms' ownership structure, among other factors.

We have also explored the existence of asymmetries in the sensitivity of firms' R&D spending to the business cycle, that is, we have investigated whether R&D spending responds differently depending on whether the firm is facing an economic downturn or an upturn, and whether these asymmetries in firms' R&D responses are also related to firms' ownership structure.

We have used for these purposes a panel data for Spanish manufacturing firms provided by the Survey of Business Strategies (*ESEE*) for the period 1990-2006, which is representative of the whole Spanish manufacturing sector by industry and size category. In order to capture the business cycle, following Aghion *et al.* (2012), among others, we have used a micro level approach, that is, we have proxied the business cycle using firms' sales growth. Regarding firms' ownership structure, we have distinguished among three types of firms, namely, family owned firms, group affiliated firms, and firms with public capital participation. These different ownership structures may provide different internal sources of finance, and thus they may alleviate the effect of credit constraints on the cyclicality of firms' R&D, especially in downturns.

Our findings strongly suggest that there is a role for firms' ownership structure in moderating the impact of business cycles in inducing firms' R&D spending. We have obtained that firms' R&D spending is countercyclical when firms do not face credit constraints, but that R&D spending in credit constrained firms reacts in a less countercyclical (or even procyclical) way to the business cycle. In addition, our findings have also revealed an asymmetric response of R&D to the business cycle, so that the sensitivity of R&D to credit constraints is more important in downturns, and shows less responsiveness during upturns. These findings are in line with empirical evidence provided by Aghion *et al.* (2012).

However, and this is our main contribution, our results indicate that under some ownership structures the procyclical role of credit constraints in R&D investments may not operate. In particular, we have found that in the case of firms that are family owned and firms that are group-affiliated the responsiveness of R&D to the business cycle is considerably less dependent on being credit constrained, and that, especially during recessions, R&D spending remains countercyclical for these firms. In the case of firms with public capital participation, however, the obtained results are somewhat more ambiguous. Thus, our findings provide evidence that some firms' ownership structures may moderate to a great extent the role played by credit constrains in explaining the cyclical behaviour of firms' R&D.

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Figure 1. Cyclical components of GDP and firms' real sales (1990-2006)

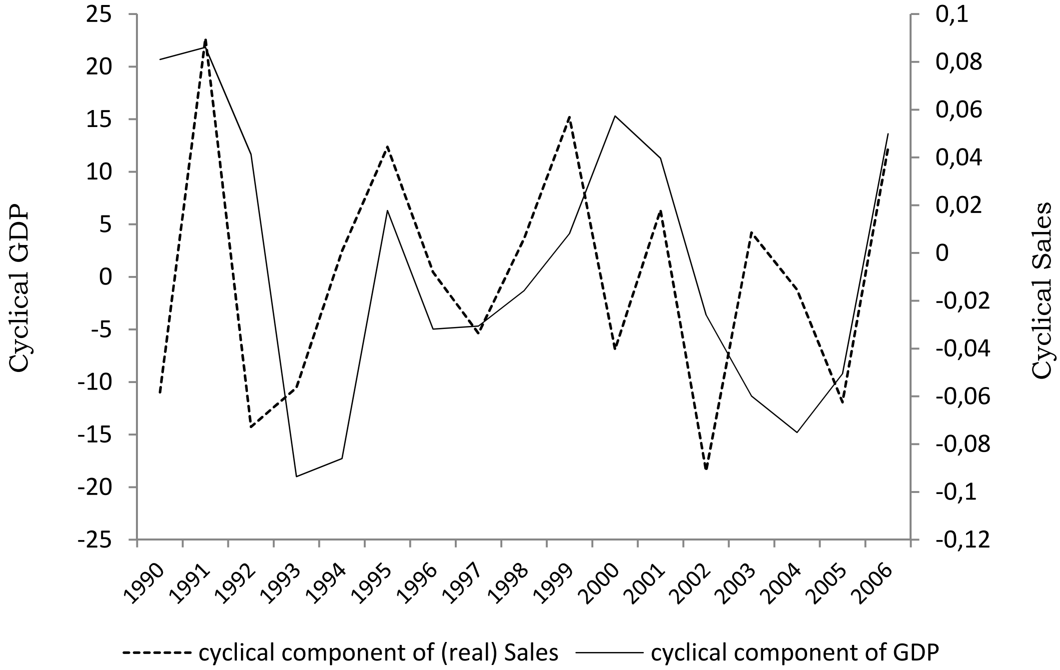

Figure 2. R&D/Sales and Sales growth
(All firms)

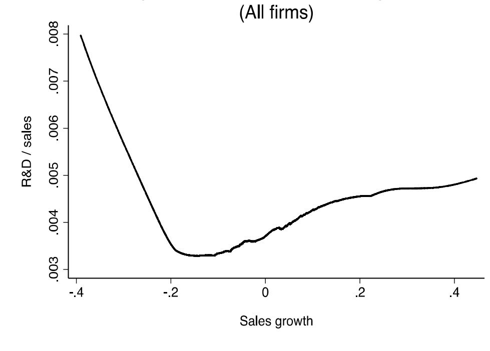

Figure 3. R&D/Sales and Sales Growth
(Credit constrained firms)

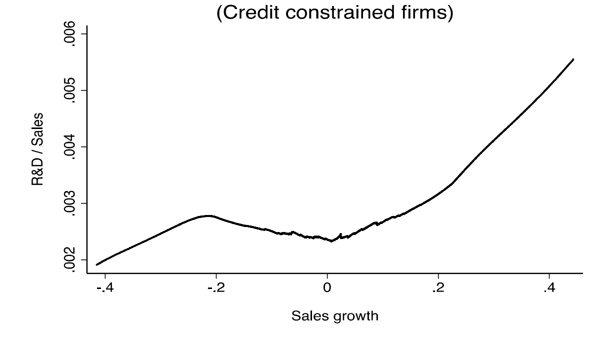

Figure 4. R&D/Sales and Sales growth
(Family owned, credit constrained firms)

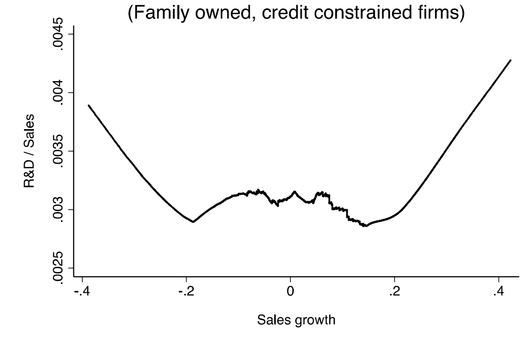

Figure 5. R&D/Sales and Sales growth
(Group affiliated, credit constrained firms)

Figure 6. R&D/Sales and Sales growth
(Public capital, credit constrained firms)

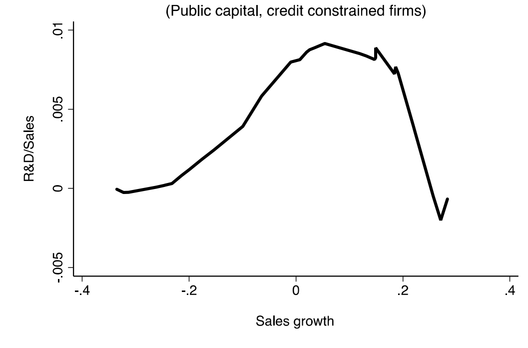

TABLE 1. Descriptive statistics: whole sample and by ownership type.

	All firms	All firms		Family owned firms		Group affiliated firms		Public capital firms	
		Yes CC	No CC	Yes CC	No CC	Yes CC	No CC	Yes CC	No CC
No. Firms	3361	1814	1547	920	570	304	630	19	49
No. Observations	20900	10638	10262	5667	3875	1590	3770	102	302
% Obs. over whole sample	-	50.90	49.10	27.11	18.54	7.60	18.03	0.48	1.45
% Obs. over its ownership type	-	-	-	59.40	40.60	29.67	70.33	25.25	74.75
% Obs. R&D>0	31.54	20.67	42.80	15.21	28.98	46.98	62.94	58.86	68.54
% Obs. R&D>0 (SMEs)	18.69	14.78	24.52	13.19	21.24	28.88	37.56	43.39	43.02
% Obs. R&D>0 (Large firms)	69.82	64031	71.56	59.27	66.66	68.03	73.21	71.42	78.70
R&D/sales (%)	1.14	1.57	0.93	2.33	1.66	0.96	0.45	1.27	3.22
Sales growth (%)	1.75	2.64	0.82	1.72	0.81	0.65	-0.15	0.64	2.21
Corr. R&D/sales with sales growth	-0.003	0.016	-0.019	-0.062	-0.143	0.050	0.132	0.288	0.084
Log of real sales	14.41	14.192	14.63	14.00	14.43	15.06	14.89	15.27	15.12
Age (years)	16.81	18.14	15.43	18.90	19.25	13.36	9.13	15.10	8.39

CC: credit constrained firms. R&D/sales calculated for positive R&D observations. R&D investment and sales in thousands of euros. SMEs: less than 200 employees; large firms: 200 or more employees. The reported values of the variables have been weighted to upgrade the number of small and large firms in the survey to Spanish manufacturing population proportions.

TABLE 2. Firms' business cycle and R&D investment: the effect of ownership.

	Panel *Tobit* for R&D investment		
Variables	(1)	(2)	(3)
$\Delta log\ s_{it}$	-1.055***	-1.549***	-1.706***
	(0.242)	(0.312)	(0.495)
CC_{it}		-0.277*	-0.422*
		(0.148)	(0.245)
$CC_{it}*\Delta log\ s_{it}$		1.257**	2.759***
		(0.494)	(0.850)
FO_{it} (Family Owned)			0.721***
			(0.249)
$FO_{it}*\Delta log\ s_{it}$			0.259
			(0.746)
$FO_{it}*CC_{it}$			0.113
			(0.315)
$FO_{it}*CC_{it}*\Delta log\ s_{it}$			-1.970*
			(1.136)
GA_{it} (Group Affiliated)			-0.017
			(0.288)
$GA_{it}*\Delta log\ s_{it}$			0.489
			(0.686)
$GA_{it}*CC_{it}$			0.361
			(0.330)
$GA_{it}*CC_{it}*\Delta log\ s_{it}$			-2.253*
			(1.165)
PC_{it} (Public Capital)			1.495**
			(0.689)
$PC_{it}*\Delta log\ s_{it}$			-2.614
			(1.597)
$PC_{it}*CC_{it}$			-0.556
			(0.878)
$PC_{it}*CC_{it}*\Delta log\ s_{it}$			0.007
			(3.213)
$log\ s_{it}$	3.810***	3.793***	3.833***
	(0.107)	(0.108)	(0.115)
Age_{it}	0.011	0.010	0.011
	(0.008)	(0.008)	(0.008)
Constant	-69.397***	-68.974***	-70.009***
	(2.080)	(2.097)	(2.192)
Log Likelihood	-26642.92	-26638.38	-26624.62
LR-test: Variance(α_i)=0	7277.47	7264.50	7251.87
(*p*-value)	(0.000)	(0.000)	(0.000)
Observations	20,900	20,900	20,900
Number of firms	3,361	3,361	3,361

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

TABLE 3. Asymmetric effects of the business cycle and ownership.

	Panel *Tobit* for R&D investment	
Variables	(1) Micro cycle	(2) Macro cycle
$Up_{it}*\Delta log\ s_{it}$	0.031	-1.041
	(0.811)	(0.646)
$Down_{it}*\Delta log\ s_{it}$	-3.431***	-3.143***
	(0.845)	(0.874)
CC_{it}	0.026	-0.355
	(0.280)	(0.246)
$Up_{it}*CC_{it}*\Delta log\ s_{it}$	-0.624	1.358
	(1.337)	(1.154)
$Down_{it}*CC_{it}*\Delta log\ s_{it}$	6.203***	4.698***
	(1.451)	(1.337)
FO_{it} (Family Owned)	0.712**	0.743***
	(0.277)	(0.249)
$Up_{it}*FO_{it}*\Delta log\ s_{it}$	0.601	-0.385
	(1.269)	(0.913)
$Down_{it}*FO_{it}*\Delta log\ s_{it}$	0.702	1.255
	(1.109)	(1.426)
$FO_{it}*CC_{it}$	-0.290	0.034
	(0.364)	(0.317)
$Up_{it}*FO_{it}*CC_{it}*\Delta log\ s_{it}$	0.374	0.365
	(1.772)	(1.457)
$Down_{it}*FO_{it}*CC_{it}*\Delta log\ s_{it}$	-5.834***	-5.520***
	(1.837)	(1.933)
GA_{it} (Group Affiliated)	0.308	0.014
	(0.308)	(0.289)
$Up_{it}*GA_{it}*\Delta log\ s_{it}$	-1.979*	-0.063
	(1.080)	(0.868)
$Down_{it}*GA_{it}*\Delta log\ s_{it}$	2.893**	1.235
	(1.174)	(1.222)
$GA_{it}*CC_{it}$	-0.300	0.310
	(0.378)	(0.332)
$Up_{it}*GA_{it}*CC_{it}*\Delta log\ s_{it}$	2.626	-0.427
	(1.729)	(1.555)
$Down_{it}*GA_{it}*CC_{it}*\Delta log\ s_{it}$	-7.317***	-4.199**
	(2.024)	(1.853)
PC_{it} (Public Capital)	2.105***	1.542**
	(0.762)	(0.693)
$Up_{it}*PC_{it}*\Delta log\ s_{it}$	-5.984**	-3.579*
	(2.438)	(2.004)
$Down_{it}*PC_{it}*\Delta log\ s_{it}$	1.604	-0.596
	(3.011)	(2.672)
$PC_{it}*CC_{it}$	-0.310	-0.265
	(1.103)	(0.894)
$Up_{it}*PC_{it}*CC_{it}*\Delta log\ s_{it}$	-2.658	-3.826
	(5.388)	(4.146)
$Down_{it}*PC_{it}*CC_{it}*\Delta log\ s_{it}$	1.491	5.248
	(5.352)	(5.486)

Cont.

log s_{it}	3.843***	3.847***
	(0.116)	(0.115)
Age_{it}	0.011	0.011
	(0.008)	(0.008)
Constant	-70.413***	-70.062***
	(2.217)	(2.192)
Log Likelihood	-26609.74	-26610.98
LR-test: Variance(α_i)=0	7258.37	7266.31
(*p*-value)	(0.000)	(0.000)
Observations	20,900	20,900
Number of firms	3,361	3,361

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

TABLE 4. Total effects of the business cycle: firms' classification by credit constraints and ownership (using coefficient estimates from the final column in Table 2).

	Non-credit constrained firms (CC_{it}=0)	Credit constrained firms (CC_{it}=1)
Other (reference category)	$\Delta log\ s_{it}$ = -1.706 (*p*-value=0.001)	$\Delta log\ s_{it} + CC_{it}*\Delta log\ s_{it}$ = -1.706+2.759= +1.053 (*p*-value =0.131)
Family Owned (FO_{it})	$\Delta log\ s_{it} + FO_{it}*\Delta log\ s_{it}$ = -1.706 + (n.s) = -1.706 (*p*-value =0.001)	$\Delta log\ s_{it} + CC_{it}*\Delta log\ s_{it}$ + $FO_{it}*\Delta log\ s_{it} + FO_{it}*CC_{it}*\Delta log\ s_{it}$ = -1.706 + 2.759 + (n.s) -1.970 = - 0.917 (*p*-value =0.328)
Group Affiliated (GA_{it})	$\Delta log\ s_{it} + GA_{it}*\Delta log\ s_{it}$ = -1.706 + (n.s) = -1.706 (*p*-value =0.001)	$\Delta log\ s_{it} + CC_{it}*\Delta log\ s_{it}$ + $GA_{it}*\Delta log\ s_{it} + GA_{it}*CC_{it}*\Delta log\ s_{it}$ = -1.706 + 2.759 + (n.s) - 2.253 = - 1.2 (*p*-value =0.233)
Public Capital participated (PC_{it})	$\Delta log\ s_{it} + PC_{it}*\Delta log\ s_{it}$ = -1.706 + (n.s) = -1.706 (*p*-value =0.001)	$\Delta log\ s_{it} + CC_{it}*\Delta log\ s_{it}$ + $PC_{it}*\Delta log\ s_{it} + PC_{it}*CC_{it}*\Delta log\ s_{it}$ = -1.706 + 2.759 + (n.s) + (n.s) = + 1.053 (*p*-value= 0.131)

This table presents coefficients associated with the corresponding variables; (n.s): statistically non-significant coefficient; *p*-values of the H_0: added coefficients=0 in parenthesis.

TABLE 5. Total asymmetric effects of the business cycle : firms' classification by credit constraints and ownership (using coefficient estimates from the first column in Table 3).

	Non-credit constrained firms (CC_{it}=0)		Credit constrained firms (CC_{it}=1)	
	UP	DOWN	UP	DOWN
Other (reference category)	$Up_{it}*\Delta log\ s_{it}$ = (n.s)	$Down_{it}*\Delta log\ s_{it}$ = -3.431 (p-value =0.000)	$Up_{it}*\Delta log\ s_{it}$ + $Up_{it}*CC_{it}*\Delta log\ s_{it}$ = (n.s)+(n.s)	$Down_{it}*\Delta log\ s_{it}$ + $Down_{it}*CC_{it}*\Delta log\ s_{it}$ = -3.431+6.203= 2.772 (p-value = 0.021)
Family Owned (FO_{it})	$Up_{it}*\Delta log\ s_{it}$ + $Up_{it}*FO_{it}*\Delta log\ s_{it}$ = (n.s)+(n.s)	$Down_{it}*\Delta log\ s_{it}$ + $Down_{it}*FO_{it}*\Delta log\ s_{it}$ = -3.431+(n.s) = -3.431 (p-value = 0.000)	$Up_{it}*\Delta log\ s_{it}$ + $Up_{it}*CC_{it}*\Delta log\ s_{it}$ + $Up_{it}*FO_{it}*\Delta log\ s_{it}$ + $Up_{it}*FO_{it}*CC_{it}*\Delta log\ s_{it}$ = (n.s)+(n.s)+(n.s)+(n.s)	$Down_{it}*\Delta log\ s_{it}$ + $Down_{it}*CC_{it}*\Delta log\ s_{it}$ + $Down_{it}*FO_{it}*\Delta log\ s_{it}$ + $Down_{it}*FO_{it}*CC_{it}*\Delta log\ s_{it}$ = -3.431+6.203+ (n.s)-5.834 = -3.062 (p-value =0.041)
Group Affiliated (GA_{it})	$Up_{it}*\Delta log\ s_{it}$ + $Up_{it}*GA_{it}*\Delta log\ s_{it}$ = (n.s) – 1.979 = -1.979 (p-value = 0.067)	$Down_{it}*\Delta log\ s_{it}$ + $Down_{it}*GA_{it}*\Delta log\ s_{it}$ = -3.431+2.893 = -0.538 (p-value = 0.542)	$Up_{it}*\Delta log\ s_{it}$ + $Up_{it}*CC_{it}*\Delta log\ s_{it}$ + $Up_{it}*GA_{it}*\Delta log\ s_{it}$ + $Up_{it}*GA_{it}*CC_{it}*\Delta log\ s_{it}$ = (n.s)+(n.s) -1.979 +(n.s) = -1.979 (p-value = 0.067)	$Down_{it}*\Delta log\ s_{it}$ + $Down_{it}*CC_{it}*\Delta log\ s_{it}$ + $Down_{it}*GA_{it}*\Delta log\ s_{it}$ + $Down_{it}*GA_{it}*CC_{it}*\Delta log\ s_{it}$ = -3.431+6.203+ 2.893-7.317= -1.652 (p-value = 0.237)
Public Capital participated (PC_{it})	$Up_{it}*\Delta log\ s_{it}$ + $Up_{it}*PC_{it}*\Delta log\ s_{it}$ = (n.s) -5.984 = -5.984 (p-value = 0.014)	$Down_{it}*\Delta log\ s_{it}$ + $Down_{it}*PC_{it}*\Delta log\ s_{it}$ = -3.431+(n.s) = -3.431 (p-value = 0.000)	$Up_{it}*\Delta log\ s_{it}$ + $Up_{it}*CC_{it}*\Delta log\ s_{it}$ + $Up_{it}*PC_{it}*\Delta log\ s_{it}$ + $Up_{it}*PC_{it}*CC_{it}*\Delta log\ s_{it}$ = (n.s)+(n.s) - 5.984 + (n.s) = - 5.984 (p-value = 0.014)	$Down_{it}*\Delta log\ s_{it}$ + $Down_{it}*CC_{it}*\Delta log\ s_{it}$ + $Down_{it}*PC_{it}*\Delta log\ s_{it}$ + $Down_{it}*PC_{it}*CC_{it}*\Delta log\ s_{it}$ = -3.431+6.203+ (n.s) + (n.s)= 2.772 (p-value = 0.021)

This table presents coefficients associated with the corresponding variables; (n.s): statistically non-significant coefficient; p-values of the H_0: added coefficients=0 in parenthesis.