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FINANCIAL CONSTRAINTS ON R&D PROJECTS AND MINSKY MOMENTS: CONTAINING THE CREDIT CYCLE.

Juan Laborda[1], Vicente Salas[2], Cristina Suárez[3*]

(1) Department of Business Administration, Universidad Carlos III, Madrid, Spain
(2) Department of Business Administration and Organization, Universidad de Zaragoza, Zaragoza, Spain
(3) Department of Economics, Universidad de Alcalá, Alcalá de Henares, Madrid, Spain, ORCID: 0000-0003-2579-0734
[*] e-mail: cristina.suarez@uah.es

Abstract

This paper tests Minsky's financial instability hypothesis (FIH) for a panel of Spanish manufacturing firms. We find that the probability of a firm being financially constrained externally in terms of undertaking innovation projects moves inversely with the business and credit cycle, which is consistent with Minsky's FIH. We provide evidence that the credit and business cycles strengthen each other. These results highlight the importance of implementing polices designed to contain the financial cycle.

Keywords: R&D; Financial constraints; Business cycle; Credit cycle; Financial instability hypothesis

JEL Classification: E12, E32, G01

1. Introduction

This paper studies the likelihood that a firm engaged in innovation projects is financially constrained, controlling the sample selection for those firms that do undertake R&D. It focuses on how the macroeconomic conditions affect the likelihood that an individual firm is financially constrained in its R&D investment, controlling for firm and industry characteristics. Knowing how the business and financial cycles affect the likelihood of a particular firm being financially constrained is, in itself, of relevance, since in practice it is difficult to disentangle supply and demand effects on the evolution of financial variables such as credit growth over the business cycle.

There is evidence that financial constraints affect investment expenditures in a different way, depending on the business cycle (Grenwald and Stiglitz 1993; Bernanke et al. 1999; Stein 2003; Aghion et al. 2012). All these neoclassical studies take the financial situation of firms as given and ignore that financial constraint is not a random phenomenon but will depend on the characteristics of the firms and on the general business environment. In this paper, we focus on how macroeconomic conditions influence the supply side of financial markets. Here, an important point of reference is Minsky's financial instability hypothesis (FIH) concerning how the bank credit cycle contributes to the financial fragility of firms.

Minsky's FIH (1984, 1985, 1986, 1992) implies that the same microeconomic conditions in a borrower-lender relationship can lead to financial constraints, or not, depending on the macroeconomic environment. In particular, the FIH predicts that the likelihood of facing credit constraints is counter-cyclical for given microeconomic conditions in the sense that it decreases in periods of GDP expansion and increases in periods of contraction. Obviously, theses externally financial constraints will affect to the firm investment decisions. Although the seminal works of Hyman Minsky refer to the effects of the leveraging cycles on

investment in tangible capital, other post-Keynesian authors have extended Minsky's theory to investment in R&D (Perez 2002; Mazzucato 2013; Mazzucato and Perez 2015; Mazzucato and Wray 2015).

Other papers (Arza and Español 2008; Lee 2012) have examined firms' financial fragility under a Minskyan taxonomy and its relationship with capital development -including R&D- using firm data as dependent variables. However, our paper tests Minsky's FIH regarding the likelihood that a firm will be financially constrained, focusing mainly on the effect of macroeconomic variables related to business and credit cycles, but controlling for differences in the characteristics of firms. We analyse how the effect of these macroeconomic variables changes depending on the financial fragility of the firms, and investigate whether the interaction between the financial cycle and the business cycle could intensify financial constraints on R&D.

The rest of the paper is organized as follows. Section 2 reviews the key areas of the literature relevant to this study and sets out the model formulation. Section 3 details the description of the sample, the variables used and the empirical results obtained. Finally, Section 4 presents the conclusions and the implications of the findings.

2. Framework and Model Development

Figure 1 shows a framework for the analysis in this paper. The aim of our analysis is to study the likelihood that a firm engaged in innovation projects is financially constrained, controlling the sample selection for those firms that do undertake R&D, in response to different influencing factors, such as firms' characteristics, business cycle, and long-term leveraged credit cycle (Minsky' FIH). Furthermore, this framework allows us to explain potential behavioural changes in response to changes in principal variables. The red numbers

in Figure 1 show the steps in the analysis: we [1] estimate the probability of a firm being financially constrained externally, then [2] calculate the predicted response to the determinants of these constraints, and finally [3] simulate potential changes as a response to changes in macro variables related to Minsky's FIH.

[Insert Figure 1]

2.1. Financial constraint and R&D

The list of proxy variables most commonly used for the characteristics of firms that can inform the likelihood of being financially constrained is quite long. It includes those variables related to the severity of information asymmetries such as age (Diamond 1989), size (Pagano and Schivardi 2003; Benfratello et al. 2008; Czarnitzki and Hottenrott 2011), belonging to a business group (Galia and Legros 2004; Tiwari et al.2008) and having foreign firms as shareholders in particular (Schiantarelli and Sembenelli 2000; Beck et al. 2006; García-Vega and Huergo 2011). On the other hand, when a firm asks for a new bank loan, the bank will decide whether, or not, to grant it taking into consideration the financial risks of the borrower. Two proxy variables for the financial risks of a firm are the leverage ratio and the cost of issued debt (Brown and Petersen2011; Brown et al.2012). The same leverage ratio will imply a higher probability of default in firms with low cash flows than in firms with high cash flows. Therefore, to properly assess the effect of leverage and cost of debt on the likelihood of being financially constrained, it is necessary to control for the cash flows of the firm too. Besides, we want to account for possible differences in the financing conditions affecting firms involved in R&D activities. One of these conditions may be the internal availability of the firm's own funds, which is accounted for by generated cash flow.

To account for differences across firms within the general situation of firms involved in innovation activities, we consider two additional variables: whether the firm has patents or not, and whether the firm receives external subsidies for its innovation activities or not.

Investments in R&D do not take place in isolation but together with investments in other assets, particularly tangible fixed investments. Investment in R&D and non-R&D assets compete for finance from the pool of internal and external funds available in a given time period. To undertake a proper assessment of the likelihood of being financially constrained in relation to R&D activities, it will be necessary to control for the level of investment in non-R&D assets in a given time period (Lopez-Garcia et al.2012).

This paper studies the likelihood that a firm engaged in innovation projects is financially constrained. However, in order to avoid sample selection bias we control the sample selection for those firms that do undertake R&D. Therefore, we include in the analysis the selection equation Do R&D investment. It is reasonable to expect that the firm level variables as an explanation for the likelihood of being financially constrained may also account for the decision to undertake R&D or not.

With respect to the R&D decision, one additional relevant variable is the expected increase in the profit margin resulting from it. Firms will decide to undertake R&D to innovate in products, processes, or both. Product innovation is expected to increase margins because the innovation will increase buyers' willingness to pay for the product; thus, the firm will be able to increase the market price and consequently the profit margin. Process innovations are more likely to seek increases in margins through lower production costs for the same price of goods.

The strategies of firms and the competitive advantage each firm seeks are not observable, so they will have to be substituted by proxy variables according to the information available.

One variable that can be informative regarding the strength of competitive advantage and also the size of the market from which incremental revenues will come is whether the firm exports or not (Melitz 2003; Aw et al. 2008, 2011; Girma et al. 2008; Bustos 2011). Other proxy variable concerns the characteristics of the products that firms produce, be they standardized or differentiated. Standardization is more likely to relate to process innovations whereas differentiation is more likely to be associated with product innovation. A priori, it is unclear whether there will be differences in the benefits and costs of undertaking R&D between the groups of firms and if so, whether these will be higher for firms with standardized products or for firms with differentiated products. Thus, product standardization is a control variable and the empirical results will reveal whether or not there is a relationship between this variable and the firm undertaking R&D.

2.2. The financial instability hypothesis, macroeconomic conditions and financial constraints

Macroeconomic conditions change over time so there is a question about the interplay between changes in the economic environment of business and changes in the conditions for accessing external finance, and the consequences with regard to the investment decisions of firms.

There is previous research looking into the sensitivity of business investment in general and in R&D in particular with respect to the monetary conditions of the economy and the stage of the business cycle. Many papers claim and provide supportive empirical evidence that R&D investment is pro-cyclical (Fatas 2000; Walde and Woitek 2004; Comin and Gertler 2006; Barlevy 2007). However, Aghion et al. (2012) criticize these papers for not taking into account the financial situation of firms. They claim that R&D investment will be more pro-cyclical in firms facing tighter financial constraints.

These studies focus on the demand side (funds, investment) of the market but it is necessary to incorporate how macroeconomic conditions influence the supply side of financial markets, as formulated in Minsky's FIH concerning the bank credit cycle. Minsky's FIH (1984, 1985, 1986, 1992) asserts that households, firms and banks are willing to adopt more risky behaviour and strategies in periods of economic boom or after a long period of high growth. Minsky argues that in such situations banks relax their risk premia and their lending criteria, accepting higher debt loads. In addition, all agents, that is, households, firms and banks, will willingly hold smaller proportions of liquid assets. Owing to this, a period of stability and high economic activity will eventually lead to more fragile financial conditions.

Given the higher debt loads, higher interest rates will further erode the fragility of the system making it more difficult to meet the interest payments on existing debt. At this point, banks will surely change their behaviour by tightening both their risk premia and their lending criteria. All this may lead to financial and/or housing market crashes, and a balance sheet recession unless governments stand ready to support aggregate demand and the economy by engaging in large deficit spending. See an excellent survey of the economic legacy of Minsky in Bellofiore and Ferri (2001), specifically those contributions referring to banking and financial crises. Nikolaidi and Stockhammer (2017) survey the literature and identify differences and similarities in the ways through which Minskyan ideas have been formalised. Most of the authors that model financial fragility in the context of economic fluctuations have been ambiguous with respect to the frequency of Minsky's cycles (Taylor and O'Connell 1985; Foley 1987; Jarsulic 1989; Keen 1995; Setterfield 2004, Lima and Meirelles 2007; Fazzari et al. 2008; Charles 2008). However different authors interpret Minsky's FIH as a basis of long waves rather than a theory of short run business cycles (Flaschel et al. 1997; Ryoo 2010, 2013). Nikiforos (2017) also introduces financial instability for the business

cycle frequency so that although financial instability refers to long swings, the experience of the last cycles shows that this kind of instability can re-emerge sooner and at a higher frequency. Connected to the idea of Nikiforos (2017) that financial instability is re-emerging sooner and at a higher frequency, Wray (2009) argues that under Minsky's analysis we are in a crisis of money manager capitalism. Although innovation and deregulation increased fragility, this crisis is more severe than previous ones due to factors such as real estate boom and bust, the rise of risky financial instruments -securitized debts and credit default swaps-, and the fiscal squeeze.

For the purpose of this work, Minsky's FIH implies that the same microeconomic conditions in a borrower-lender relationship may or may not lead to financial constraints depending on the macroeconomic environment. In particular, the FIH predicts that the likelihood of facing credit constraints is counter-cyclical in the sense that it decreases in periods of GDP expansion and increases in periods of contraction. This hypothesis is based on the assumption of herd behaviour in the lending decisions of banks. Bank managers tend to make lending decisions "following the crowd" as a way of showing a pattern of behaviour and performance similar to those of their peers. Under the hypothesis of herd behaviour, over time the perception of external constraints by firms with a given credit risk will vary inversely with the credit cycle that we present in this paper with the aggregate level of indebtedness in the economy.

It is important to note that this herd behaviour, on behalf of the banks, is an evolutionary process as a consequence of the progression of risk appetite during an economic expansion. The core of Minsky's FIH is built upon a simple idea: during an economic expansion investors' risk appetite tends to increase; the longer the expansion, without major setback, the higher the risk appetite. In the finance's language: the risk premia required by investors

will tend to decline as an expansion persists, that is to say the required real-return on capital will tend to fall. In summary, this is no more than asserting that investors learn from experience, gaining confidence as a result of good economic conditions.

Minsky described the evolution of risk appetite by defining three phases of finance according to their degree of risk: hedge finance, speculative finance, and Ponzi finance. In Minsky's taxonomy, an asset acquired with hedge finance is purchased at a relatively low value, therefore the income earned from the asset more than covers the servicing cost of the debt used to acquire it. As a result, over time, the owner of an asset bought with hedge finance is able to pay down the debt, and the holding becomes stable. By contrast, an asset acquired with speculative finance is purchased at a higher value, such that the income earned from the asset barely covers the debt service costs. Investors holding assets funded in this way are reliant on continually rolling their borrowing, being exposed to the risks of rising borrowing costs, or declining liquidity. Finally, Ponzi finance, Minsky's riskiest phase. In this case assets are purchased at a very high value, such that their running yield is insufficient to cover the investor's cost of capital. In this type of finance an investor's stock of debt rises continually, as money is borrowed to meet interest payments. Investors purchasing assets on this basis are, presumably, expecting to generate a profit by reselling the asset at an even higher value, hence the Ponzi label. In Minsky's model, an economic expansion begins as investors initially acquire assets on Hedge finance valuations, progressing through Speculative, and finally into Ponzi valuations during the mature stage of the expansion.

One additional issue in terms of the links between macroeconomic conditions and firms' perception of external financial constraints is the point in time at which the lenders change expectations with regard to the future conditions of the whole economy and decide to alter their credit policy. A reasonable hypothesis is that central banks will make their monetary

policy decisions according to inflation expectations. If this hypothesis is correct, future, rather than current, inflation will trigger changes in monetary policy. This will in turn be perceived by individual borrowers (firms) in the form of a tightening or softening of financial conditions. If observed future inflation is a good indicator of ex ante expected inflation and current financial conditions, the hypothesis is that inflation in period $t+1$ is positively associated with a higher probability of perceiving financial constraints by firms in time period t. Other approaches as indicators to current financial conditions, like credit spreads, present problems of interpretation due to specific temporal and idiosyncratic market conditions (Laborda and Laborda 2009).

One final issue is whether it is reasonable to expect that macroeconomic conditions will affect equally all firms regardless of their own internal situation or, on the contrary, the same macro conditions will affect firms differently depending on their financial situation. To account for these possible differences, the explanatory variables include the cross product of GDP growth in period t times the ratio of cash flow over total assets of the firm also in period t.

2.3. Is R&D investment important in the Minsky model?

It is not possible to directly draw from Minsky's work the importance of R&D investment in his theory of boom-bust leverage cycles because it focuses only on tangible assets. However the importance of R&D investment is present in the works of other post-Keynesian economists who have continued and extended the Hyman Minsky theory (Perez 2002; Mazzucato 2013; Mazzucato and Perez 2015; Mazzucato and Wray 2015).

Mazzucato and Wray (2015) discuss the role that finance plays in promoting the capital development of the economy. The financial system has evolved to one in which financial markets dominate the system, producing the greatest explosion of financial innovation in history. Most of this financial innovation was directed not to funding capital investment

opportunities but to speculative investments, thereby increasing financial fragility that ended in The Great Recession. With regard to capital development they use a broad definition which includes innovations and human knowledge. The reason is that the latest knowledge, techniques, and processes will usually promote the capital development of the economy so that economic development can be the result of innovation becoming a key to long-run growth. The aim of the authors is to explore how to restructure finance in order to produce both innovation-led growth and full employment, bringing together the thinking of Keynes, Minsky, and Schumpeter.

Mazzucato and Wray (2015) recognise the absence in Minsky's approach of the innovation and dynamism in the nonfinancial sector and therefore the importance of R&D. However, they explain that there is more and more literature that tries to incorporate Schumpeter's work to the Minsky approach in order to examine innovation and structural transformation of the real sector, linking Schumpeterian analysis to finance (Perez 2002, Mazzucato 2013, Mazzucato and Perez, 2015). Thus, while Schumpeterian evolutionary analysis provides insights into the dynamics of structural/technological change in the real economy, Minsky's approach offers a theory of money and financial fragility, which is virtually lacking in Schumpeterian models. Mazzucato and Wray's synthesis between these approaches seeks to link the real economy with the monetary economy and provide a theory of innovation in both the financial and non-financial sectors.

There is additional research (Whalen 2001; Knell 2014) that also connects Minsky's FIH to Keynes and Schumpeter. Whalen (2001) points out that not only the financial structure is a central determinant of a capitalist economy in Minsky's theory but also the driving force of profits. In Minsky's writings profit-driven structural change affects to capitalist development. Therefore, Schumpeter and Keynes are integrating in Hyman Minsky's theory of capitalist

development. Minsky emphasizes that Schumpeter not only recognizes forces of creation and destruction in products and manufacturing processes but also gives attention to changes in financial systems.

Knell (2014) will focus on how Minsky related some ideas from Schumpeter's Theory of Economic Development with those in Keynes' General Theory of Money and Finance, providing a link between Keynes' view of the investment decision as a determinant of output and employment with Schumpeter's view of the investment decision as a determinant of innovation and economic growth.

2.4. Econometric model for determinants of financial constraints and R&D

Our prime interest here is to identify the determinants of the financial situation of firms (constrained or unconstrained). However, we have argued that being financially constrained, in terms of undertaking R&D activities, is not independent of the decision to undertake R&D activities. Here we have used the Heckman sample selection approach to deal with the selectivity bias resulting from the non-random subsets of firms that have not implemented R&D activities. The Heckman model allows us to consider different determinants that affect the undertaking of R&D activities as well as the determinants of financial constraints. Therefore, we consider two interrelated steps in the external financial constraints on R&D: (i) The undertaking of R&D activities, and (ii) the financial situation of firms.

Sample selection often arises in practice because of the partial observability of the outcome variable. When sample selection is present, the data missing in the sample do not respond to a random selection process. Thus, a standard analysis using only complete cases will lead to biased results. From what we have just said, this model is reduced to two equations:

$$C_i = \mathbf{1}[\gamma' Z_i + \varepsilon_{1i} > 0] \qquad (1)$$

$$Y_i = \mathbf{1}[\beta' X_i + \varepsilon_{2i} > 0]\ C_i\,,\ \forall\, C_i = 1 \qquad (2)$$

where $i = 1, \ldots, n$ are firms, $\mathbf{1}[\cdot]$ is the indicator function that denotes if firm i performed R&D (C_i) for equation (1) and if firm i unsuccessfully sought financing for its R&D (Y_i) for equation (2); Y_i is not observable, $\forall\, i\colon C_i = 0$. X_i and Z_i are vectors of variables that collect individual characteristics, which may or may not be common in the specifications of equations (1) and (2). ε_{1i} and ε_{2i} are, respectively, the error terms for equations (1) and (2), distributed according to a bivariate normal with zero mean and unit variance and $\rho = Corr(\varepsilon_{1i}, \varepsilon_{2i})$. The model allows for correlation between the unobservable information of equations (1) and (2). As is well known, when $\rho \neq 0$, the standard probit model applied to equation (2) produces biased results and the probit model with sample selection produces consistent and asymptotically efficient estimators for all model parameters. If $\rho = 0$, the standard probit model applied to equation (2) produces consistent and asymptotically efficient estimators for all model parameters.

3. Empirical Analysis

3.1. Sample and variables

The econometric models formulated to respond to the questions posed on the determinants of a firm being financially constrained and the effects of being constrained at the level of R&D expenditure are estimated with data from Spanish manufacturing firms collected by the Survey on Business Strategies (*Encuesta sobre Estrategias Empresariales*, ESEE) conducted annually by the SEPI Foundation (*Fundación SEPI*). The range of firms surveyed by the ESEE includes manufacturing firms operating in Spain with 10 or more employees. All manufacturing firms with 200 or more employees are included in the survey, while firms with between 10 and 199 employees are represented by a sample that is statistically

representative across manufacturing sectors. The ESEE started in 1991 and is run annually. However, the question of whether a firm is financially constrained in terms of undertaking R&D projects was first included in the 1998 survey. Therefore, the data used in this work, comprise panel data on individual firms from 1998 to 2011 for a total of 18,096 firm year observations and no fewer than 1,010 firms for each year.

Table 1 summarizes the variables used in equation (1) and (2) taking into account the analysis contained in the previous section. It incorporates variables included in X_i and Z_i that refer to firm characteristics that may influence either both probabilities or only one of them. In addition, this set of variables included in X_i and Z_i, contains those that explain how time variation in macroeconomic conditions affects financial constraints to carry out R&D activities. This set of variables will be introduced in two different ways: using temporal dummies or employing specific macroeconomic variables.

[Insert Table 1]

Table 2 presents descriptive statistics, means and standard deviations, for all the variables in the estimated models, separating all firms in the database from those that engage in R&D. Those that do, on average have higher volumes of sales, are older, are more likely to belong to a business group and have foreign control, have patents and receive public subsidies. However, on average, the financial conditions (leverage, cost of debt, cash flows) of R&D firms are not particularly different from those of the whole population of manufacturing firms. The Variance Inflation Factor (VIF) for explanatory variables was calculated and the average VIF factor is 1.30 and so does not show any problem of collinearity.

[Insert Table 2]

3.2. Empirical results

3.2.1 Results of financial constraints and R&D

We now present the results of the estimation of equations (1) and (2), corresponding to the likelihood of a firm being financially constrained, taking into account that this firm belongs to the group of firms that undertake R&D (sample selection). The results of the estimation appear in Table 3. We report two sets of estimations. In the first, we use those selected variables to capture the macroeconomic environment of the business. In the second, we focus on the micro or firm-level variables and use the binary time variables as the control variable for the time evolution of macroeconomic conditions.

[Insert Table 3]

The joint test of goodness of fit of the estimated model confirms its statistical significance: $\chi^2(42) = 258.65^{***}$ and $\chi^2(33) = 245.02^{***}$ for the model with temporal dummies and for that with the macroeconomic variables, respectively. Moreover, the statistical test of the null hypothesis that the correlation coefficient ρ between the residuals of the main and the selection equations would be equal to zero is rejected at $p<5\%$. These results confirm the importance of using the selection equation for undertaking R&D to avoid biases in the joint estimation of the probability that a firm will be financially constrained in looking for external funds.

The first set of estimations with the binary time variables, controlling for the macroeconomic conditions common to all firms, confirm most of the predictions advanced with regard to the effects of the characteristics of firms on the likelihood of a firm being financially constrained. The likelihood is lower among larger and older firms than among smaller and younger ones, and is also lower among firms that belong to a business group and among firms owned and controlled by non-resident shareholders than among independent and national firms, although the estimated coefficient is significant only for the variable, foreign ownership. Financial risks are positively associated with the likelihood of being financially constrained:

the estimated coefficients of leverage and the cost of debt are both positive and statistically significant. Higher cash flows over total assets and having access to public subsidies lower the likelihood of a firm being financially constrained (negative estimated coefficients), although the only statistically significant coefficient is that of the public subsidies variable. The estimated positive coefficient of the variable Patents is consistent with the hypothesis that the likelihood of being financially constrained is greater among firms with more intangible assets than among firms with less intangible, all else being equal. Investing more or less in tangible assets does not affect the likelihood that a firm will report being financially constrained in innovative projects.

The estimated coefficients of the binary Time variable are positive and statistically significant, with similar values for all of them until the year 2005, and are non-statistically significant between 2006 and 2010. In 2011, the estimated coefficient is again positive and significant. A detailed analysis of the data allows us to find some evidence within a long term wave of the existence of short term waves. With respect to 2007 (reference year), it is observed two local maximums of greater credit restriction before the Great Recession: 2000 and 2005, both statistically significant. In 2000, there was a risk aversion increase in the financial markets and, consequently, an upturn in corporate credit spreads which increases the probability of credit restrictions. In 2005 the European Central Bank increased the official interest rates with the same observed result of increasing the probability of not been able to find funding. Similar empirical results on the long/short-run-waves debate can be found in Stockhammer et al (2019) for seven OECD countries.

All this evidence suggests that there was a time lag, between 2003 and 2006, before the manufacturing firms perceived more relaxed external financial constraints in the period of

high credit expansion and a time lag between 2009 and 2011, in the middle of the financial crisis, before the proportion of firms reporting financial constraint again increased.

The panel on the right of Table 3 shows the results of the estimation in which the binary Time variable was replaced by variables capturing the business and credit cycle of the Spanish economy. The goodness-of-fit of the model and the joint determination of the selection and the financial constraint equations are maintained (correlation coefficient significantly different from zero). The estimated coefficient of the inflation expectation variable is positive and significant, which suggests that lenders anticipate the future tightening of monetary policies in current lending decisions. The estimated coefficients of the business and credit cycles variables, that is, *GDP growth* and *(Debt Non-Financial Companies/GDP)* are negative and significant. For a given level of credit quality, lenders relax credit conditions in a period of expansion in the business cycle and tighten them in periods of contraction. At the same time, as the credit cycle evolves with a greater accumulation of aggregate corporate debt, firms of a given credit quality find it easier to obtain external finance, confirming the predicted herd behaviour of lenders. The estimated coefficient of the interaction between the business cycle and the internal availability of funds *(GDP growth multiplied by Cash flow/Assets)*, is not significant, meaning that the effect of the business cycle on the perception of external financial constraints does not vary with the availability of internal funds in each firm. The macro variables effects and signs we obtain show strong evidence in favour of Minsky's FIH about the relationship between the business and the financial cycle. It reflects the progression of risk appetite and the debt accumulation process, showing that the access to external finance by firms, and probably their investment decisions, are sensitive to the business cycle beyond the sensitivity resulting from their own particular financial conditions. We note that in this specification of the model, the estimated coefficient of *Cash flow/Assets*

is negative and statistically significant. This means that the availability of internal funds lessens the likelihood that a firm will face external financial constraints. As a consequence of these results and more specifically the non-significance of the interaction between macro and micro variables, the estimated coefficients cannot be used to analyse periods of credit and business cycle boom and bust in relation to internal finance (we tried with other multiplicative variables but we didn't improve the presented results)

The estimated coefficients of the selection equation on the probability that a firm undertakes R&D are very similar in the two model specifications. As expected, the likelihood that a firm will be active in R&D increases with size and age and is greater among firms that have patents than among firms that do not. Foreign ownership and higher financial risk, in particular a higher cost of debt, lower the likelihood of doing R&D. The leverage and cash flow variables are not statistically significant. Firms that invest more in tangible assets in period *t-1* are more likely to engage in R&D in period *t*, so R&D activity tends to follow capacity expansion investment. The likelihood of R&D activity is higher for exporters and lower for those firms that report standardized products. These results are very much in line with those seen in previous research works (Melitz 2003; Aw et al. 2008, 2011; Bustos 2011). As anticipated, except when justified, for example in the case of foreign ownership, the estimated coefficients of the common variables in the two equations show opposite tendencies: the variables that positively (negatively) affect the likelihood of being financially constrained negatively (positively) affect the likelihood of undertaking R&D.

The estimated coefficients of the binary Time variable in the R&D equation show a decreasing trend from 1998 and stabilize around low non-significant values from 2003 onward (except for particular years in which they are positive). Coinciding with the first years in the Euro zone, controlling for individual characteristics, the proportion of Spanish

manufacturing firms engaging in R&D progressively decreased to a lower value and remained there until 2003. Perhaps being part of the Euro zone, with lower interest rates and credit expansion, increased external competition for Spanish manufacturing firms and some of them realized that engaging in R&D was not the right way to respond to this increase in competition and so ceased doing so. It is probable that the candidates for ceasing R&D activity were those firms that were perceived to have the highest external financial constraints.

With regard to the macroeconomic conditions, the only estimated coefficient that is statistically significant is that of corporate sector leverage, which is negative. So the time pattern of the estimated coefficients of the binary Time variable is probably captured by the evolution of the corporate debt to GDP ratio. This ratio increased over the whole period and at a higher rate in the years in which the proportion of firms engaged in R&D was decreasing. As the expansion of the debt ratio also coincides with the construction and real estate bubble, the combination of the real estate and credit bubbles was not the most favourable situation for stimulating R&D activity among Spanish manufacturing firms.

3.2.2. Focusing on financial instability hypothesis effects

We want to go more deeply into the analysis of Minsky effects captured by the macro variables. Two different macroeconomic variables capturing additional effects are introduced, in order to confirm the robustness of previous results. Table 4 presents the same macroeconomic analysis as on the panel on the right of Table 3 but introducing these two additional effects. Firstly, on the right of Table 4, we investigate how the financial cycle variable changes depending on the financial fragility of the firms. In order to do that, we incorporate a new multiplicative variable, *Debt Non Financial Companies/GDP* multiplied by *Debt with cost/Liabilities(-1)*. This variable is intended to capture the interaction of two

effects whose impacts on the probability of facing financial constraints are opposite. Higher aggregate debt ratios reduce the probability of firms facing R&D financial constraints, but higher debt of individual firms raises the probability of firms' reporting financial constraints. Therefore, its impact on the probability of not finding funding for R&D is expected to be negative. In combination with the explanatory variable *Debt Non Financial Companies/GDP* it is possible to determine over what level of the *Debt with cost/Liabilities(-1)*, the impact of the credit cycle increases the probability of not finding financing for R&D.

Secondly, on the left of Table 4, we want to investigate whether the credit and business cycle strengthen each other. In order to do that we incorporate a new multiplicative variable, *Debt Non Financial Companies/GDP* multiplied by *GDP Growth*, but eliminate the *GDP Growth* and the *Debt Non Financial Companies/GDP * Debt with cost/Liabilities(-1)*, as explanatory variables in order to avoid collinearity. It is expected that if economic activity increases (decreases) and, at the same time, the debt of non-financial companies over GDP expands (decreases), then the credit and business cycles reinforce each other and the probability of not finding financing decreases (increases). Therefore, a negative sign is expected for this variable.

[Insert Table 4]

About the first, how the financial cycle variable changes depending on the financial fragility of the firms, the estimated coefficient of the interaction between the aggregate debt and the debt of individual firms is positive and significant. The *Debt Non Financial Companies/GDP* estimated coefficient is (-0.492+0.649**Debt with cost/Liabilities(-1)*), positive for values of *Debt with cost/Liabilities(-1)* above 0.75. As the mean of the ratio of *Debt with cost/Liabilities(-1)* for the sample data is 0.25 (SD=0.20) (see Table 2), the estimated coefficient of the *Debt Non Financial Companies/GDP* for the mean value of the *Debt with*

cost/Liabilities(-1) variable is negative. These results indicate that higher aggregate debt ratios reduce the probability of firms facing R&D finance constraints among firms with *Debt with cost/Liabilities(-1)* around the sample mean. On the other hand, only among firms with relatively high indebtedness ratios (above 75%), the estimated coefficient of aggregate debt ratio will be positive. Therefore, among these firms the probability of firms facing R&D finance constraints will increase.

Dealing with the second effect, that is, the possibility that the credit and the business cycle will strengthen each other, the estimated coefficient of the interaction between the aggregate debt and GDP growth is negative and significant. The estimated coefficient obtained for the *Debt Non Financial Companies/GDP* is (-0.229-2.068**GDP growth*), negative for values of *GDP growth* above -0.11%. That means higher aggregate debt ratios reduce the probability of firms facing R&D financial constraints in periods of positive economic growth. However, in recessions, lower *Debt Non Financial Companies/GDP* increases his probability. These results imply that the credit and business cycles could strengthen each other. So macro-prudential policies should be developed to contain the financial cycle. If we have leverage cycles the answer lies in controlling credit expansion ex ante rather than punishing debtors ex post.

Figures 2 and 3 present simulated predicted probabilities for not finding R&D funding in terms of the credit cycle from estimated coefficients of Table 4.

[Insert Figure 2]

[Insert Figure 3]

Figure 2 plots the predicted probabilities for not finding R&D funding as a function of the credit cycle, given by the variable *Debt Non Financial Companies/GDP*. There are two probabilities linked with *Debt with cost/Liabilities(-1)*: the linear effect and the multiplicative

interaction effect. All these values are calculated for a representative firm, given by the average for continuous variables and the median for qualitative variables. Vertical lines represent the values for *Debt Non Financial Companies/GDP* for 2002, 2008, and 2011. In 2002 the linear effect was higher than the multiplicative one. The opposite happened in 2008 and 2011. The probability of the joint effect is higher in 2002 (19.57%, z-statistic= 3.75***) than in 2008 (15.34%, z-statistic= 3.05***), corresponding to a period of boom and the debt accumulation process. However, these probabilities are slightly higher in 2011 (15.41%, z-statistic= 3.07***) than in the year of the beginning of the crisis, i.e. 2008, in line with Minsky's FIH. From 2008 and due to the higher debt loads, once the collateral of this debt collapsed, firms were left with excess liabilities, forcing them into debt minimization mode. On the other hand, the Spanish bank system needed to recapitalize, closing off credit and thus producing a credit crunch.

Figure 3 investigates whether the credit and business cycles strengthen each other. It plots the predicted probabilities for not finding R&D funding as a function of the credit cycle, given by the variable *Debt Non Financial Companies/GDP*. All these values are calculated for a representative firm, given by the average for continuous variables and the median for qualitative variables. Vertical lines represent the values for *Debt Non Financial Companies/GDP* for 2002, 2008, and 2011. In 2002 the linear effect was higher than the multiplicative variable. The opposite was the case in 2008 and 2011.The probability of the joint effect is higher in 2002 (19.27%, z-statistic= 3.75***) than in 2008 (15.88%, z-statistic= 3.14***), as the boom in credit and business cycles strengthen each other. However, the simulated probabilities are again slightly higher in 2011 (15.94%, z-statistic= 3.15***) than in the year of the beginning of the crisis, i.e. 2008, in line with Minsky's FIH. In 2011, both

the deleveraging process of Spanish non-financial companies, which implied a reduction in this debt over GDP with respect to the 2008 levels; and the lower GDP growth in 2011 than in 2008 meant a higher probability of not finding R&D funding. Therefore, these results are again consistent with Minsky's FIH.

4. Conclusions

This paper studies the probability of firms suffering external financial constraints in implementing investment projects in R&D. We provide three main contributions to research on this question. Previous works have investigated how macroeconomic and business cycle conditions affect business investment in R&D and whether the cyclical conditions have different effects on those that are financially constrained and those that are not. However, much less is known concerning how macroeconomic conditions affect the probability that a firm will be financially constrained in undertaking innovation projects. Our data base is particularly suitable for examining this issue because it covers a time period within which Spain joined the Euro zone and experienced several years of unprecedented investment and credit expansion, followed by a period of economic decline with a double-dip recession.

Controlling for firm and industry characteristics, we find, first, that the probability of a firm being financially constrained externally in terms of undertaking innovation projects moves inversely with the business and credit cycle. In other words, it decreases with the growth rate of GDP and with the leverage ratio of non-financial corporations. We also find that the decision of whether or not to engage in R&D appears to be dependent only on the characteristics of firms and is not sensitive to the business cycle, which suggests that the likelihood of being financially constrained is independent of the possible pro-cyclicality of the decision to undertake R&D. On the contrary, the likelihood of being externally

constrained is negatively correlated with the level of corporate leverage for the whole economy, a result that is consistent with Minsky's theory on the positive correlation between the business and financial cycles, i.e. the FIH.

We provide empirical evidence that the credit cycle and the business cycle mutually strengthen each other: in periods of high and cheap liquidity, firms with given credit characteristics, including financial risk, find it easier to access external finance and invest more than would be optimal if the investment decision were to take into account the whole business cycle. This overinvestment contributes to higher growth in the economy and firms respond with more investment and more demand for external finance and so on. When the credit cycle changes tendency, for example as a result of a change in monetary policy motivated by inflation expectations, the reinforcement serves to accelerate contraction in investment and the demand for external finance.

From a policy perspective, the results of the paper highlight the importance of implementing polices with the purpose of containing the financial cycle through ex-ante controls of credit expansion, which is better than punishing debtors ex-post. The mutual reinforcement of the two cycles detected in this paper probably causes higher volatility in employment and economic growth than would be desirable for maximizing social welfare. So containing the credit cycle would bring social benefits. The macro-prudential regulation of banks, implemented in response to the experience of the current financial crisis, appears to be a step in the right direction, but the answer to the question of whether macro-prudential regulation has been successful or not in achieving the desired decoupling will have to wait until we see the effects on the future evolution of real and financial variables.

Conflict of Interest:

The authors declare that they have no conflict of interest.

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Table 1.-Variables Description

Variable	Definition	Reason of use	Equation
Dependent variables			
C_i	Dummy variable for firms that invest in R&D	Dependent variable for the R&D decision and expresses the status of every firm	(1)
Y_t	Dummy variable for firms that unsuccessfully sought financing	Dependent variable for a firm being financially constrained for its R&D. It is only observed if previously companies have done R&D	(2)
Independent variables			
Sales	Sales expressed in euros in real terms by employing the individual firm deflator calculated from the yearly variation in the prices of their products.	Proxy of the company size. Smaller firms are more likely to face binding financing constraints than larger firms, because the latter can more easily attract outside funding as there will be less informational asymmetry for outside investors.	(1) (2)
Age	Number of years since the firm was founded.	Younger firms are expected to be subject to greater restrictions on external financing because it is more likely they suffer especially severe information problems.	(1) (2)
Group Membership	Dummy variable for firms that belong to a business group.	If the firm belongs to a corporate group that provides a signal to outside investors, then it could facilitate the process of gathering resources.	(1) (2)
Owned by Foreign Capital	Dummy variable for firms with non-residents holding a proportion of shares of the firm above 50%	Firms with some degree of foreign ownership enjoy less bankruptcy risk and adopt international standards faster, and therefore they access to debt easier.	(1) (2)
Debt with cost/Liabilities	Ratio between external funds available and total volume of liabilities	Firms with lower financial risk will be in a better position to obtain a fraction of debt to finance investments	(1) (2)
Cash Flow/Assets	Ratio between internally generated cash flows and total volume of assets	When a firm chooses to hold a high level of cash flow this may be an indicator that it is subject to credit restrictions, holding cash for precautionary reasons	(1) (2)
Debt Average Cost	The weighted average of the cost of long and short term debt with cost	Outside investors, to alleviate informational asymmetries, can increase the debt cost	(1) (2)
Investment in equipment/Assets	Ratio between investment in equipment and total volume of assets	R&D projects may compete for funds with other investment projects, then in times of high investment rates in tangible capital, R&D projects have more difficulty getting financed.	(1) (2)
Sectorial dummies	Dummy variables for firms that belong to manufacturing sub-sector j, for 20 manufacturing sub-sectors NACE class (two-digit) level	These variables are introduced to control the effect of the technological level of the sectors in which the firms operate.	(1) (2)
Public subsidies	Dummy variable for firms with public subsidies to R&D activities.	The main purpose of these subsidies is to reduce the effective cost of R&D and therefore to increase firms' R&D spending.	(1)
Patents	Dummy variable for firms with patents in Spain and/or abroad	This variable measures a way to verify the R&D effort for outside investors.	(1)
Export activities	Dummy variable for firms with export activities	R&D is typically seen as a major drivers of productivity growth and thus also for export activities.	(2)
Standardized Products	Dummy variable for firms that produce and sell standardized products.	R&D projects contribute to develop new products and improve the quality of these products	(2)
Real GDP growth	Annual percentage change in Spanish GDP at constant prices	In periods of economic boom, firms and banks are willing to adopt riskier behaviour. In such a situation banks and financial markets ease their lending criteria accepting higher debt loads.	(1) (2)
GDP Deflator	Annual percentage change in the Spanish GDP Deflator	The forward looking inflation can be used to anticipate a tightening in monetary policy and so an increase in the cost of debt.	(1) (2)
Debt Non-Financial Companies/GDP	Ratio of the total debt of Spanish non-financial companies over Spanish nominal GDP	It captures the progression of risk appetite and the debt accumulation process. During an economic expansion investors' risk appetite tends to increase; the longer the expansion, without any major setback, the higher the risk appetite and the access to find funding for R&D.	(1) (2)

Table 2.-Descriptive statistics of principal variables

	Total sample		Subsample R&D	
	Mean	Std. Dev.	Mean	Std. Dev.
Sales (in thousands)	69267.42	314142.10	147398.30	483481.20
Age	28.93	21.83	35.89	24.78
Group membership (% of firms)	36.23	48.07	58.72	49.24
Owned by foreign capital (% of firms)	17.05	37.61	30.05	45.85
Patents (% of firms)	6.60	24.83	13.38	34.05
Debt with cost/Liabilities	0.25	0.20	0.23	0.19
Cash Flow/Assets	0.10	0.77	0.11	1.21
Public funding (% of firms)	12.85	33.46	31.57	46.48
Debt Average Cost	0.05	0.01	0.04	0.01
Investment in equipment/Assets	0.03	0.05	0.03	0.04

Table 3.- Estimation of the probit model with sample selection

	Model with temporal dummies						Model with macro variables					
	Don't find funding for R&D			*Do R&D*			*Don't find funding for R&D*			*Do R&D*		
	Coef.	Std. Error		Coef.	Std. Error		Coef.	Std. Error		Coef.	Std. Error	
Log(sales)	-0.115	(0.039)	***	0.385	(0.010)	***	-0.115	(0.040)	***	0.384	(0.010)	***
Log(age)	-0.058	(0.033)	*	0.010	(0.017)	***	-0.057	(0.033)	*	0.010	(0.017)	***
Group membership	-0.037	(0.054)		0.016	(0.030)		-0.033	(0.054)		0.016	(0.030)	
Owned by foreign capital	-0.201	(0.061)	***	-0.158	(0.036)	***	-0.207	(0.061)	***	-0.158	(0.034)	***
Patents	0.255	(0.061)	***				0.252	(0.061)	***			
Debt with cost/Liabilities(-1)	0.400	(0.122)	***	0.070	(0.059)		0.413	(0.121)	***	0.069	(0.059)	
Cash Flow /Assets (-1)	-0.211	(0.142)		0.011	(0.024)		-0.476	(0.245)	**	-0.084	(0.088)	
Debt Average Cost (-1)	4.081	(2.004)	**	-2.365	(0.997)	**	2.953	(1.941)		-2.287	(0.964)	**
Public subsidies (-1)	-0.206	(0.051)	***				-0.206	(0.051)	***			
Investment in equipment/Assets	0.309	(0.497)					0.262	(0.484)				
Investment in equipment/Assets(-1)				0.945	(0.230)	***				0.909	(0.225)	***
Export activities				0.553	(0.030)	***				0.553	(0.030)	***
Standardized product				-0.153	(0.026)	***				-0.152	(0.026)	***
1998	0.356	(0.130)	***	0.281	(0.064)	***						
1999	0.363	(0.123)	***	0.286	(0.059)	***						
2000	0.450	(0.121)	***	0.177	(0.060)	***						
2001	0.308	(0.125)	**	0.126	(0.061)	**						
2002	0.400	(0.119)	***	0.138	(0.058)	**						
2003	0.401	(0.123)	***	0.050	(0.061)							
2004	0.374	(0.123)	***	0.094	(0.060)							
2005	0.454	(0.123)	***	0.085	(0.061)							
2006	0.104	(0.136)		0.048	(0.063)							
2008	0.001	(0.129)		0.042	(0.057)							
2009	0.111	(0.126)		0.100	(0.058)	*						
2010	-0.104	(0.135)		0.121	(0.058)	**						
2011	0.225	(0.125)	*	-0.006	(0.058)							
$\chi^2(13)$	53.06	***		48.68	***							
GDP Deflator (+1)							7.553	(2.661)	***	-1.826	(1.401)	
GDP Growth							-3.583	(2.030)	*	-0.965	(1.008)	
Debt Non Financial Companies/GDP							-0.344	(0.125)	***	-0.333	(0.063)	***
GDP Growth * (Cash Flow /Liabilities)							10.092	(7.399)		3.022	(2.653)	
Sectorial dummies included												
$\chi^2(19)$	69.23	***		1093.37	***		68.64	***		1092.68	***	
Constant	0.286	(0.933)		-7.610	(0.178)	***	0.776	(0.904)		-7.073	(0.200)	***
LR test of indep. eqns. ($\rho = 0$): $\chi^2(1)$	4.46	**					4.36	**				
Censored obs.	11,115						11,115					
Uncensored obs.	6,981						6,981					
Log pseudolikelihood	-10025.2						-10038.7					

Note: (***) significant coefficient at 1%; (**) significant coefficient at 5%; (*) significant coefficient at 10%.

Table 4.- Estimation of the probit model with sample selection and with macro variables

	Don't find funding for R&D			*Do R&D*			*Don't find funding for R&D*			*Do R&D*		
	Coef.	Std. Error		Coef.	Std. Error		Coef.	Std. Error		Coef.	Std. Error	
Log(sales)	-0.117	(0.040)	***	0.384	(0.010)	***	-0.115	(0.040)	***	0.384	(0.010)	***
Log(age)	-0.059	(0.033)	*	0.100	(0.017)	***	-0.057	(0.033)	*	0.100	(0.017)	***
Group membership	-0.034	(0.054)		0.016	(0.030)		-0.032	(0.054)		0.016	(0.030)	
Owned by foreign capital	-0.207	(0.061)	***	-0.158	(0.034)	***	-0.207	(0.061)	***	-0.158	(0.034)	***
Patents	0.253	(0.061)	***				0.252	(0.061)	***			
Debt with cost/Liabilities(-1)	-0.244	(0.378)		0.088	(0.205)		0.411	(0.121)	***	0.068	(0.059)	
Cash Flow /Assets (-1)	-0.430	(0.247)	*	-0.085	(0.089)		-0.465	(0.244)	*	-0.089	(0.088)	
Debt Average Cost (-1)	3.065	(1.936)		-2.289	(0.964)	**	3.062	(1.935)		-2.301	(0.962)	**
Public subsidies (-1)	-0.208	(0.051)	***				-0.205	(0.051)	***			
Investment in equipment/Assets	0.273	(0.484)					0.278	(0.484)				
Investment in equipment/Assets(-1)				0.909	(0.225)	***				0.908	(0.225)	***
Export activities				0.553	(0.030)	***				0.553	(0.030)	***
Standardized product				-0.152	(0.026)	***				-0.152	(0.026)	***
GDP Deflator (+1)	7.716	(2.660)	***	-1.835	(1.405)		8.004	(2.919)	***	-1.308	(1.519)	
GDP Growth	-3.392	(2.035)	*	-0.968	(1.008)							
Debt Non Financial Companies/GDP	-0.503	(0.153)	***	-0.329	(0.078)	***	-0.229	(0.114)	**	-0.298	(0.061)	***
GDP Growth * (Cash Flow /Liabilities)	8.033	(7.505)		3.053	(2.671)		9.677	(7.358)		3.196	(2.648)	
Debt Non Financial Companies/GDP * Debt with cost/Liabilities(-1)	0.654	(0.357)	*	-0.018	(0.184)							
GDP Growth * Debt Non Financial Companies/GDP							-2.608	(1.583)	*	-1.002	(0.774)	
Sectorial dummies included												
$\chi^2(19)$	69.60	***		1092.82	***		68.61	***		1092.52	***	
Constant	0.992	(0.909)		-7.076	(0.204)	***	0.607	(0.913)		-7.127	(0.199)	***
LR test of indep. eqns. ($\rho = 0$): $\chi^2(1)$	4.68	**					4.37	**				
Censored obs.	11,115						11,115					
Uncensored obs.	6,981						6,981					
Log pseudolikelihood	-10037.0						-10038.5					

Note: (***) significant coefficient at 1%; (**) significant coefficient at 5%; (*) significant coefficient at 10%.

Figure 1.-Overall approach and methodology.

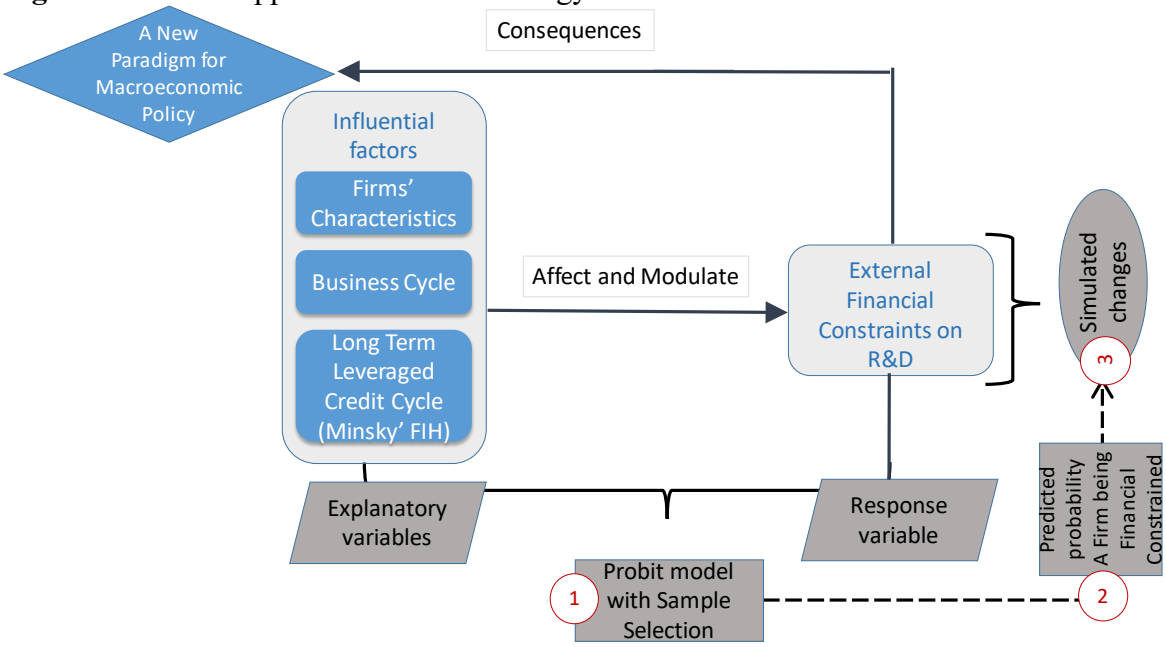

Figure 2.-Predicted probabilities for not finding funding for R&D

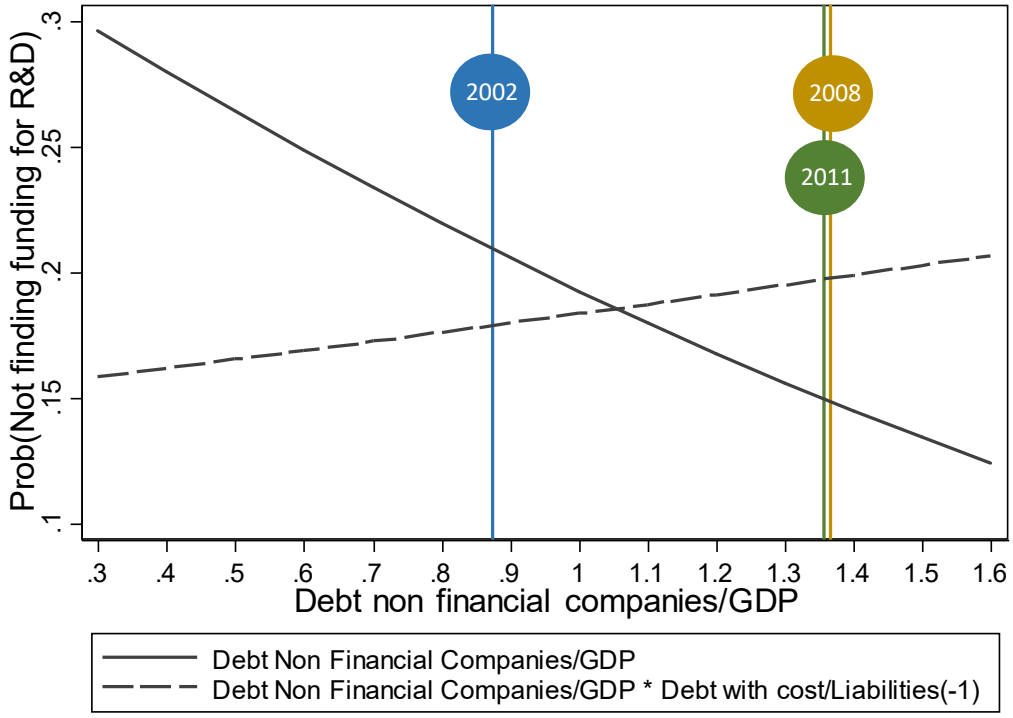

Figure 3.-Predicted probabilities for not finding funding for R&D